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ROY WALDO MINER

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PATTERNS OF EVOLUTION*

By HORACE E. WOOD, 2ND**

The three interrelated major aspects of evolution should be distinguished carefully. Both logically and historically, the first consideration is whether evolution did in fact occur. As far as scientists are concerned, this has long been settled affirmatively and merits no further discussion. The second question concerns the mechanism of evolution, and the third deals with the historical course of evolution. So far, paleontology has played a secondary, although important, part in interpreting the mechanism of evolution: the most plausible hypothesis based on neobiological evidence must meet the test as to whether it can account for the observed paleontological data. Paleontologists, then, describe the evolutionary patterns developed by their "historical" research as summaries of the observed data for their intrinsic interest and also as checks on proposed interpretations of the mechanism of evolution. Paleontology is primarily a historical discipline which traces the course of evolution from the beginning of the Cambrian to the present time, calculated by the radioactive chronology as on the order of 500,000,000 years. These limits are set to the current scope of paleontology because our information about Precambrian life is so exceedingly sketchy that only the most tentative inferences can be drawn concerning it.

* This paper, illustrated with lantern slides, was presented at a meeting of the Section on April 5, 1954.
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** Professor of Biology, Rutgers University, Newark, N.J., and Research Associate in Fossil Mammals, American Museum of Natural History, New York, N.Y.

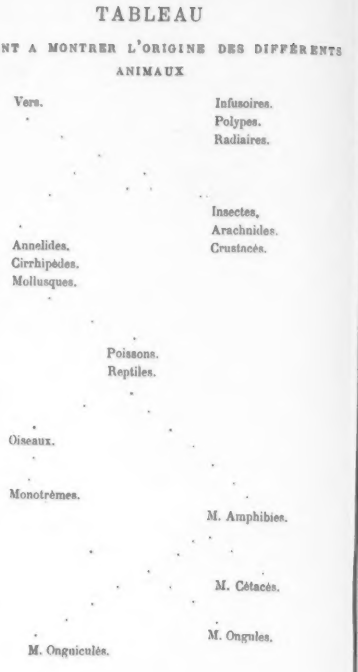

FIGURE 1. Lamarck's first phylogenetic diagram, dating from 1809.

What kinds of evolutionary patterns are known and how may they be presented for analysis? The phylogenetic tree is the standard visual method by which authors show the pattern of evolution as they see it. It might be interesting, first, to summarize the phylogeny of the phylogenetic tree, a subject touched briefly by Jepsen (1944) and by Mayr, Linsley, and Ursinger (1953). Phylogenetic diagrams date from Lamarck (1809 and 1815). Although Lamarck also speaks of a "graduated ladder," his diagrams introduce the concept of evolutionary divergence (FIGURE 1). After Lamarck, nothing deserves mention until the famous "diagram" in which Darwin (1859) illustrated his concept of "divergence of character" operating over 14,000 generations

(FIGURE 2). Like so much of Darwin's work, this "diagram" (as Darwin always called it) is strikingly sound in terms of modern science: on the supraspecific level, it is still hardly possible to improve it; on the intraspecific level, it is sound but a shade incomplete. Why are they "phylogenetic trees?" Haeckel's (1866) graphic illustrations are the answer; Agassiz (1869) cited Haeckel's "arbres généalogiques" as if both name and concept were already a commonplace (FIGURE 3). Recently, what may be called a "lattice" pattern has been used by Moody (1953) to represent the later evolution of man, with initial incipient divergence of local races, followed by fusion, in a complicated, reticulate pattern.

Phylogenetic trees have sometimes been criticized as hypothetical, dogmatic, evanescent, and even unscientific, compared with supposedly more solidly based results of science. The psychological reasons for this ultra critical attitude are hard to understand: no one criticizes the benzene ring for not being a photographic representation of the "true" situation; as to the changeability of phylogenetic trees, at least as much of last century's work still survives in the best current work as in, for example, physiology or chemistry.

Sample modern phylogenitic diagrams illustrate visual representations of data. The American Museum model of insect phylogeny (FIGURE 4) is a true three-dimensional tree. Colbert's giraffe phylogeny (1935) gives a three-dimensional effect in two dimensions. In Osborn's family tree of the perissodactyls (FIGURE 5), the relatively unidirectional horse record contrasts with the multidirectional rhinoceros pattern. The

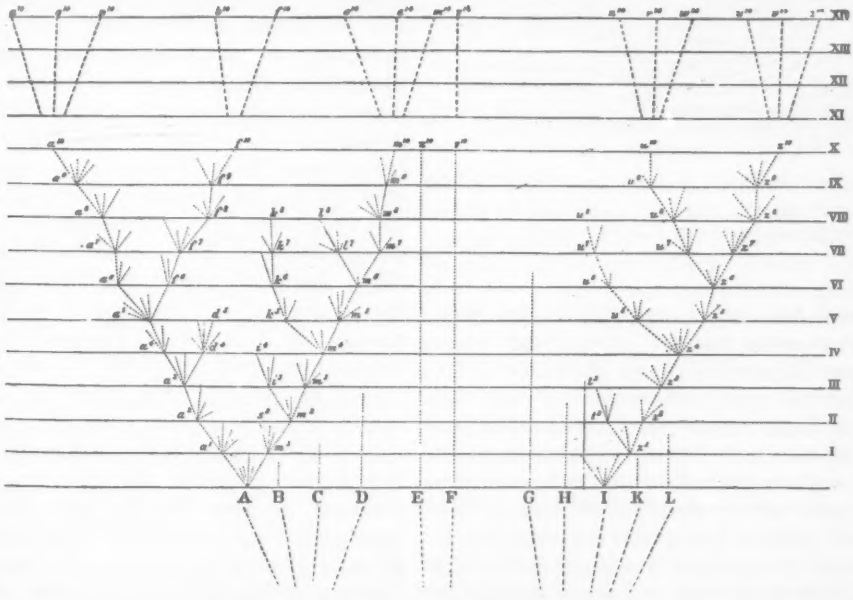

FIGURE 2. Darwin's "diagram" (1859, opposite page 117).

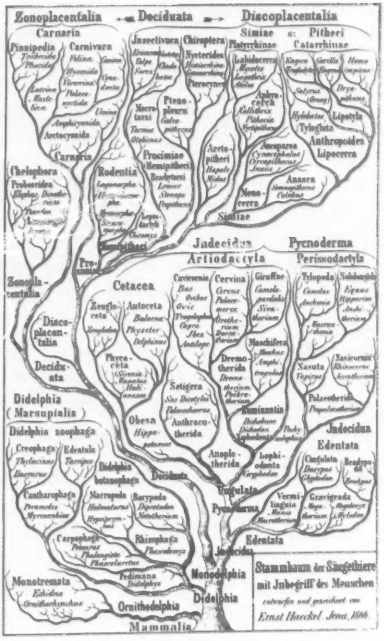

FIGURE 3. Haeckel's (1866) genealogical tree of the mammals, the last of eight such charts.

same data may be presented in other ways, as in radial charts of perissodactyl evolution (Osborn, 1929, figure 30; Simpson, 1951, figure 21), with concentric rings representing the geological epochs, proceeding from the center to the periphery. In contrast, Clark's polygonal chart, with concentric layers inching inward (1930, page 254) is one more of the steadily recurring hypotheses of spasmodic evolution. Goldschmidt (1940) is the most recent and probably the most distinguished proponent of this spasmodic approach.

The horse phylogeny was the first to be worked out in detail. It is, of course, still the best, taking into account both length of time covered and exactitude of detail. Gaudry (1865) hinted at descent of the modern horse from *Hipparion*; Haeckel (1866, Taf. 8) showed *Anchitherium*, *Hipparion*, and *Equus* in an ascending series (FIGURE 3); and perhaps Leidy (1869) had some such succession in mind. Huxley (1870) based the first explicit horse phylogeny on European fossil forms, in four pages of text without illustrations, considering it a "particular case... that... will stand rigorous criticism." Kovalevsky (1873 and 1876) traced the European sequence in detail. Marsh (1874) explicitly recognized the American horse sequence as an evolutionary series. Huxley (1877), on his American visit, became convinced that the Yale collections approached the true horse lineage much more closely than did the European series and, in his New York address of Sept. 22, 1876, delivered at Chickering Hall, stated categorically that the American succession closely approximated a true evolutionary lineage and was the first such lineage to be demonstrated. Huxley's authority and literary skill led to much more rapid general scientific acceptance of this interpretation than would otherwise have occurred. Simpson (1944, figure 15) shows diagrammatically the geographic and phylogenetic relation between the American and European horse successions. Matthew's (1903) famous diagram of the evolution of the horse has been constantly and deservedly refigured in textbook after textbook; but the success of this and similar selective diagrams has encouraged the idea that the horse record illustrates (or even proves) orthogenesis. Modern authoritative horse phylogenies (Stirton, 1940, phylogenetic chart, and Simpson, 1951, figure 13) show that the horse phylogeny should actually be repre-

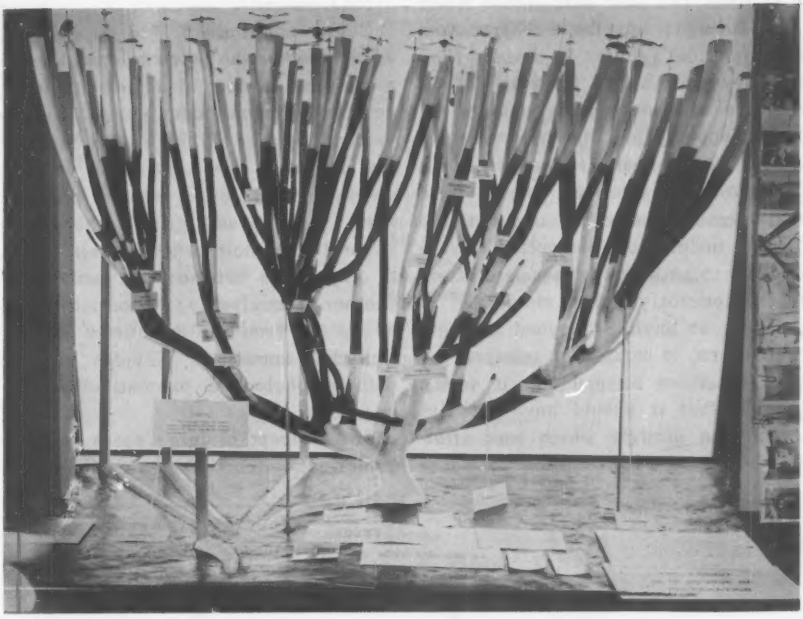

FIGURE 4. Phylogeny of the insects represented as a three dimensional tree. Photograph of an exhibit in the Insect Hall of the American Museum of Natural History. (Courtesy American Museum of Natural History, New York, N. Y.)

sented as a branching tree, like practically all other well documented cases, but with somewhat sparser branching (or divergence) than average. If a special monophyletic daemon is required to explain the horse lineage, we should need a diphyletic daemon to have sponsored the evolution of the cat family, and so on up to, or possibly beyond, a tricaedecaphyletic daemon presiding over rhinoceros diversification. Somewhat similar ideas were recently proposed by a distinguished scientist, in his later years, but have not secured general acceptance.

Turning to rhinoceroses, my special field of investigation, Gaudry (1864) offered the first hint of an evolutionary succession. Cope (1879) made the first phylogenetic diagram, which he extended in 1880; Dollo (1885) further extended it. Appropriately, Gaudry (1888) gave the first detailed rhinoceros lineage (FIGURE 6). Pavlow (1892) extended and improved Gaudry's work and used the lateral dimension to show geographic distribution, including the American record, although in somewhat sketchy fashion (FIGURE 7). Osborn (1898 and 1900) gave the first balanced treatment of Old World and New World forms. The best demonstrated lineages of Old World rhinoceroses (FIGURE 8) are those of the hornless aceratheres and of the tandem-horned European dicerorhine rhinoceroses (of which the living Sumatran rhinoceros is a collateral descendent). These two lineages were already outlined by Gaudry (1888) and Pavlow (1892), indicating that sound work on phy-

logeny may survive for quite a respectable length of time. The best established North American lineages are the *Subhyracodon-Diceratherium* line (FIGURE 9), already foreshadowed by Osborn and Wortman (1894), and the line of American amynodonts. Of detailed lineages, this line of American semiaquatic rhinoceroses (FIGURE 10) is the closest approach to a strictly monophyletic line that I know; however, in contrast, the still largely undescribed Mongolian amynodonts appear to be a typical example of exuberant rhinocerotic polyphyleticism. If orthogenesis, as anything beyond a purely descriptive term, is required to interpret the record of American amynodonts, it seems inexplicable that it should have lost its potency at the straight which was afterwards to become the international date line and still later the eastern margin of the "Iron Curtain."

Cuvier and Darwin held opposing views as to whether the paleontological record is a complete history of a discontinuous process or a discontinuous record of a gradual process. Sumner (1929) pointed out cogently that disputes over continuous versus discontinuous evolution should properly be over large versus small discontinuities, since discontinuities are certainly present, if only those between one individual and another. Conceivably, discontinuities might be usually small but sometimes large. Thus "ploidy" sometimes provides new plants with morphological discontinuities of fair magnitude.

The concept of large scale saltation in evolution, which I like to call neocreation-

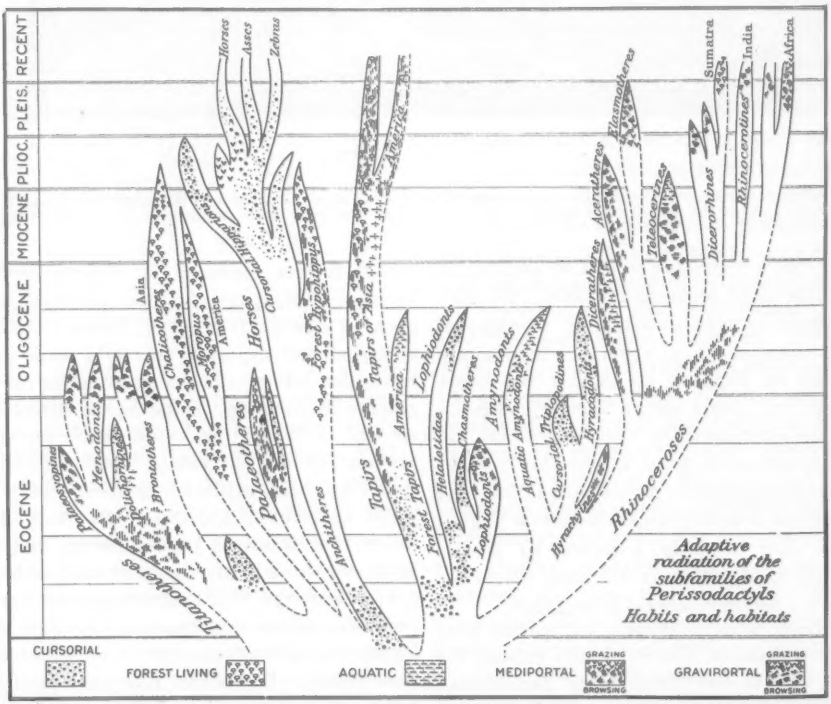

FIGURE 5. Osborn's (1929, figure 32) family tree of the perissodactyls.

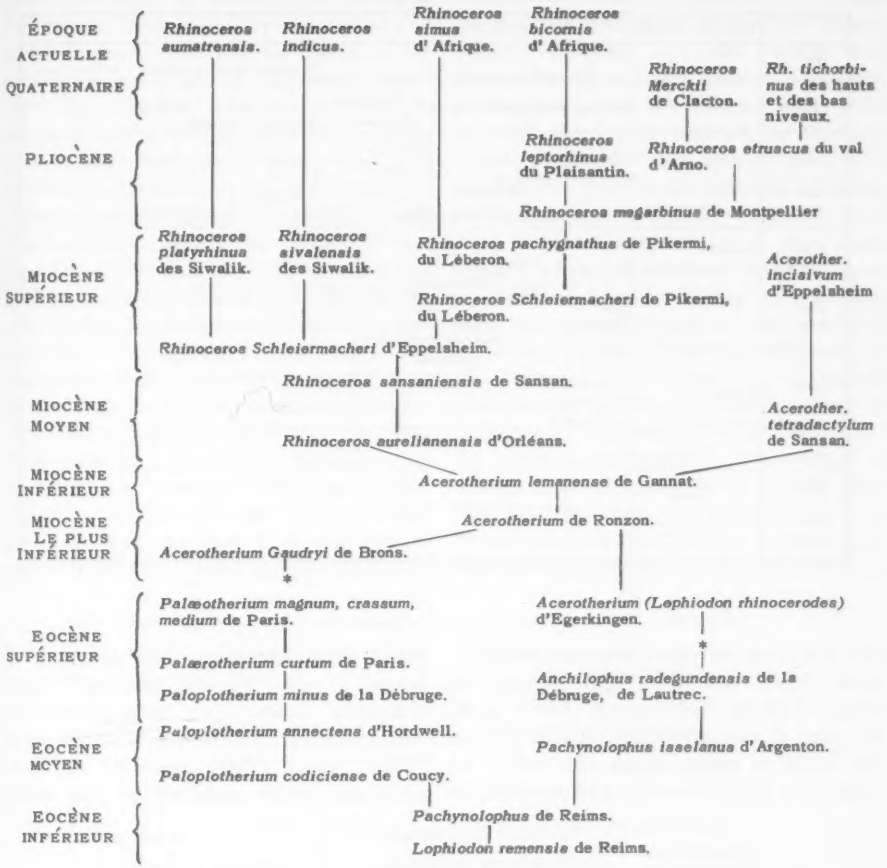

FIGURE 6. Gaudry's (1888) phylogeny of the old world rhinoceroses.

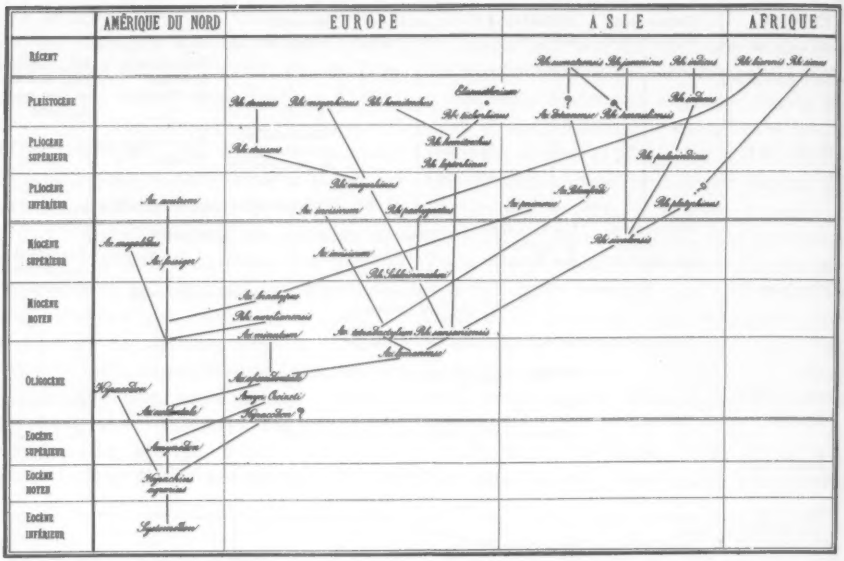

FIGURE 7. Pavlov's (1892) phylogeny of rhinoceroses of both hemispheres.

ism, has been revived at frequent intervals. Clark (1930) called on it to explain the origin of phyla. Goldschmidt (1940), under the name of macroevolution, tried to explain the origin of major groups (by which he apparently meant everything above the subgenus, and, frequently, the species), by means of his "hopeful monster." Goldschmidt's views have been extensively criticized (e.g., Dobzhansky, 1941; Simpson, 1944). Jepsen (1944; page 91) bases an additional valid criticism on the strati-

		European dicerorhines	Aceratheres
Pleistocene	Magdalenian, Moustierian	*Coelodonta antiquitatis*	
	Acheulean	*"Dihoplus" mercki* intergradation reported	
	Chellean	*"Dihoplus" etruscus*	
	Sicilian	*"Dihoplus" etruscus*	
Pliocene	Astian	*"Dihoplus" leptorhinus*	
	Plaisancian	*"Dihoplus" leptorhinus*	
	Pontian	*"Dihoplus" schleiermacheri*	*Aceratherium incisivum*
Miocene	Vindobonian	*"Dihoplus" hispanicus*	
		"Dihoplus" simorrensis	*Aceratherium tetradactylum*
	Burdigalian	*"Dihoplus" sansaniensis*	*Aceratherium depereti*
		"Dicerorhinus" tagicus	
	Aquitanian	*"Dicerorhinus" tagicus*	*Aceratherium lemanense*
Oligocene	Upper Stampian		
	Middle Stampian	*"Dicerorhinus" tagicus tolosanus*	*Aceratherium lemanense*
		Protaceratherium albigense	

FIGURE 8. The classical sequences of European fossil rhinoceroses, brought down to date (cf. FIGURES 6 and 7).

graphic record: "If catastrophic structural changes in linear phyla were a common or actual mode of evolution, we could not expect them to occur in all lines simultaneously, and yet, in many instances in the stratigraphic record, this might appear to be and has been cited as the case." The "sudden" deployment of the orders of placental mammals with the early Tertiary was doubtless Jepsen's unstated prize example. Actually, the evidence against Goldschmidt's hypothesis is of exactly the same kind as, although much less in magnitude than, that against the validity of the Lamarckian factor: that whenever either is checked against reliable positive evidence, it conspicuously fails to satisfy the data. Thus, since Goldschmidt presents his hypothesis of systematic mutations as having universal validity rather than as something that might possibly be true in special cases, it conflicts head on with the paleontological record. For example, the lineage of the horse, proceeding by the most gradual stages, produces a total change from *Hyracotherium* to *Equus* which is far greater in magnitude than the changes which Goldschmidt says *must* proceed by fits and starts. Simpson (1944) pointed out that a much better case could be made for saltatorial or quasi-saltatorial evolution at a much higher taxonomic level than Goldschmidt's "macroevolution." Simpson called it "megaevolution," taking his example from the diversification of the orders of placental mammals near the beginning of the Tertiary (1944; figure 16). If Simpson once leaned toward this interpretation, he abandoned it completely (1953, chap. 11). As to the related question of the origin of mammals, Goldschmidt (1940, p. 388) says that the "decisive phylogenetic step [for transforming the reptilian jaw and ear region into the mammalian] must have been a single

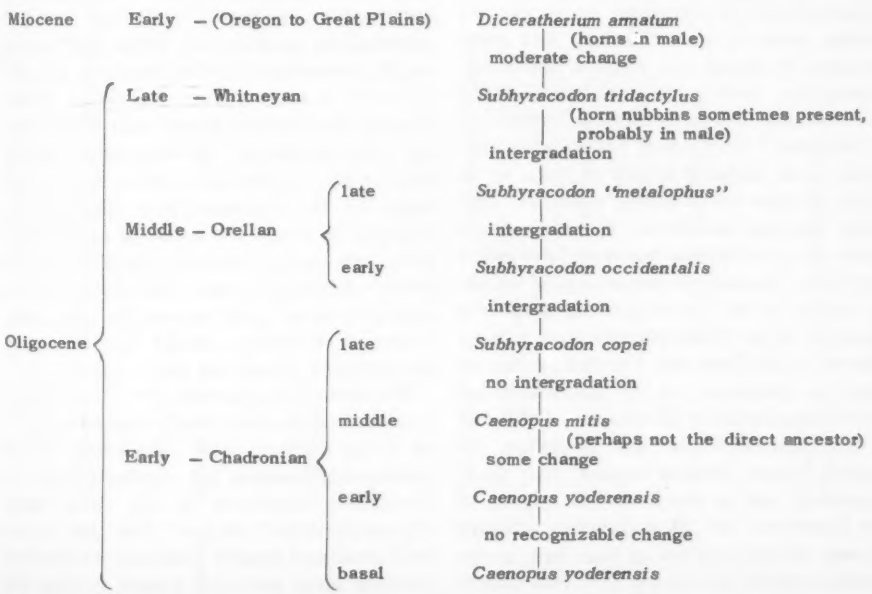

FIGURE 9. The best evolutionary lineage among American caenopine rhinoceroses.

mutation affecting an embryonic rate." Whatever Goldschmidt thinks the case should have been by deductive reasoning from his hypothesis, the relevant facts are known and flatly contradict him. The transition from a generalized reptile to something that is a mammal by every common sense criterion except current taxonomic convention is documented by abundant graduated material from the Permian and Triassic periods, especially from the Karroo of South Africa, including all major parts of the skeleton, not forgetting jaws and ears (Olson, 1944; Gregory, 1951). Thus the real, as opposed to the nominal, origin of the Class Mammalia was just as gradualistic a process as the horse lineage itself.

If Darwin (1859) had postulated a hypothetical structural intermediate between reptiles and birds, he could not have invented anything which so exactly splits the difference as does *Archaeopteryx* (Heilmann, 1926). Even here, the sciolists must have their field day: they claim that, since *Archaeopteryx* is classified as a bird, in leading manuals of ornithology and paleontology, it cannot link reptiles and birds. Presumably, such a link, if found, would be recognized at once as either a "repird" or a "birptile." On the next higher taxonomic level, it is almost a matter of faith or, at least, of repeated confident assertion, that phyla are not connected by intermediate forms. As a statistical summary, this statement has a reasonable percentage of validity, which is not too surprising since the principal phyla of invertebrates were already present in the Cambrian. For that matter, so were the chordates, if the graptolites are really hemichordates (Kozlowski, 1947) and if the hemichordates are chordates. Of course, some workers regard the hemichordates, not as the lowest subphylum of the chordates, but as a distinct, although closely related, phylum of their own, a distinction which recalls the jibe that modern scholarship has proved that the Iliad and Odyssey were not written by Homer, but by another man of the same name. However, intermediate forms between certain phyla do actually occur. Zoologists would generally agree that the Annelida and Arthropoda are standard examples of distinct though surely related phyla. It has long been recognized that *Peripatus* bridges the gap between these two phyla in many respects, but professional opinion finally settled down to treating it, and the Class Onychophora which it composes, as the most primitive of Arthropoda. For some reason, the exciting evolutionary implications of Hutchinson's (1930) restudy of Walcott's genus, *Aysheaia*, from the Middle Cambrian Burgess shale seem to have been generally overlooked. Walcott considered it a marine annelid, but Hutchinson shows that it is really an onychophoran broadly comparable to *Peripatus*, but having a terminal mouth as in annelids, and, presumably, gills and not tracheae. These characters shift the balance from classifying *Aysheaia* as a primitive arthropod to giving it either an exactly intermediate position, or, while still being validly referable to the Onychophora, slightly to the annelid side of the fence. Illustrating the implicit ground rule that phyla are not connected by annectant forms, Hutchinson, in this same paper, and on the basis of the evidence here summarized, proposed to merge the Annelida and Arthropoda into one phylum for which he would revive Cuvier's name Articulata. There seems to be no good reason why this very important discovery should upset a long standing and convenient arrangement.

Botanists long regarded the ferns (Pteridophyta) and the seed plants (Spermatophyta) as being distinct phyla. Discovery of the association between the vegetative and reproductive structures of the seed ferns (Cycadofilicales) showed that this group held an almost exactly intermediate position between ferns and seed plants, having the vegetative structures of the former and the

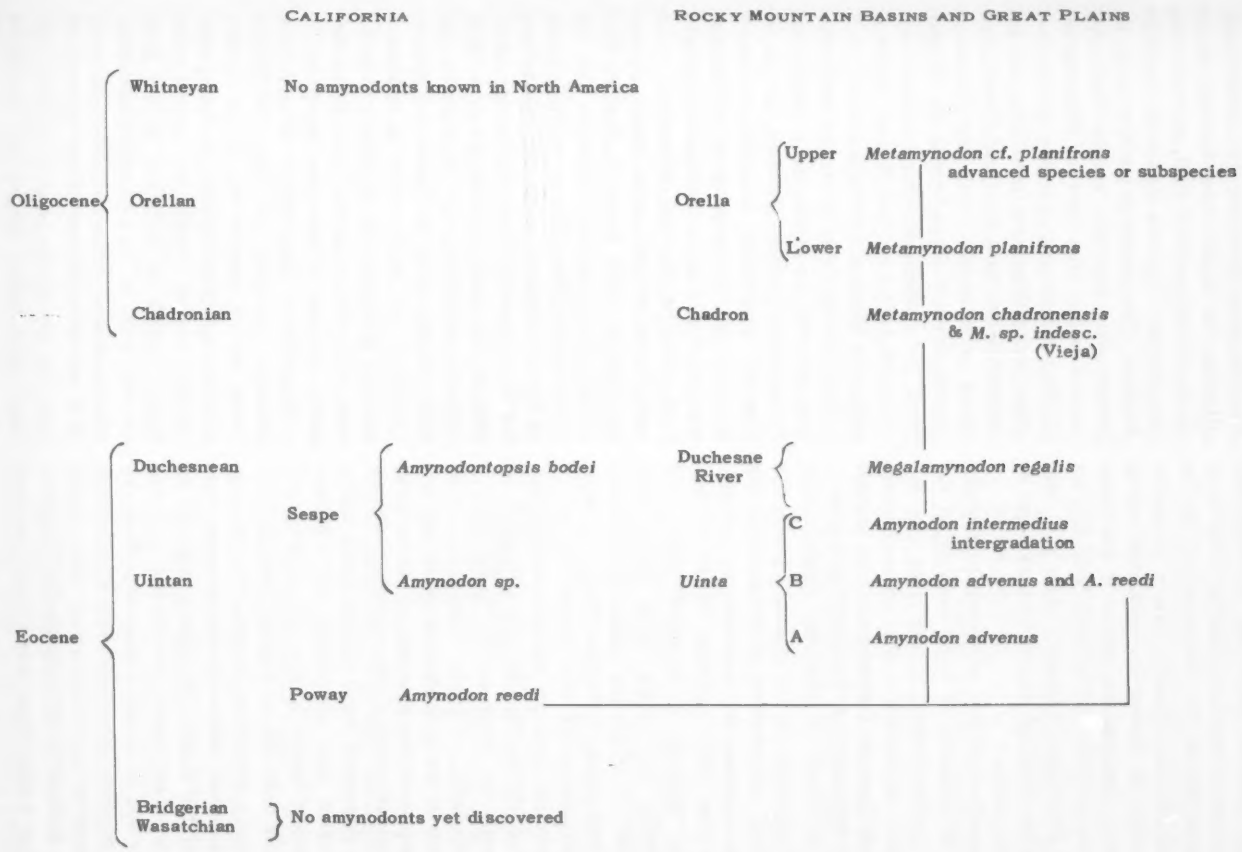

FIGURE 10. Distribution and inferred relationships of American amynodont rhinoceroses.

reproductive structures of the latter. The current standard botanical classification, which lumps everything from the ferns up in a single phylum, the Tracheophyta, may be a subconscious attempt to avoid the inconvenience of having an annectant group squarely between two phyla. If the reproductive structures of the seed ferns had not been discovered, botanists might still consider the Pteridophyta and Spermatophyta as distinct phyla.

Visually similar evolutionary patterns may be produced in lines evolving at the most extraordinarily diverse rates. As the extreme conservative, the genus *Lingula* extends from the Ordovician to the present time. Mammals are generally progressive, but the family Didelphiidae extends from the Cretaceous to the present. Among the typically progressive perissodactyls, the tapirs represent the conservative extreme: their feet have remained in an Eocene stage, retaining a four-toed manus and three-toed pes; their cheek teeth have reached an Oligocene stage of evolution, and their skull, a Miocene stage, in terms of the typical perissodactyl norm.

Generally speaking, rhinoceroses evolved less rapidly than horses, and so might conveniently be measured in "horse units." Nevertheless, different rhinoceros lines evolved at the most diverse rates, and different parts of the same animal also evolved at contrasting rates. Thus the living African white rhinoceros and the Pleistocene woolly rhinoceros are comparable to Pliocene horses in crown height of cheek teeth, whereas their feet more nearly compare with Oligocene three-toed horses. The elasmotheres, while definitely rhinoceroses, outhorsed the horses in grazing adaptations of their cheek teeth, specifically in crown height and in enamel corrugation. From the late Miocene until their extinction toward the end of the Pleistocene, their cheek teeth evolved in the same general direction as, but further than, horse teeth evolved from the middle Miocene to the present. Over the same time, their feet evolved only slightly, also in the horse direction, *i.e.*, in emphasis on the third digit, approximating the advance of horses from early to middle Miocene. The baluchitheres are by far the largest land mammals known. Since they became extinct after the early Miocene, most of this extraordinary increase in size took place during Oligocene time. Their feet had become rather more advanced toward functional monodactyly than the contemporaneous lower Miocene horses. On the other hand, the evolutionary stage of their teeth compares best with late Eocene horses or with early Oligocene rhinoceroses.

The modern wealth of paleontological data presents an increasingly satisfactory evolutionary picture. However, as an unfortunate by-product, it makes taxonomic treatment of this *embarras de richesse* almost inevitably unsatisfactory. For example, I am currently studying *Hyracodon*, a cursorial horse-like rhinoceros. Simpson's general diagram (1944, figure 31. Phyletic Evolution) almost exactly illustrates the data as I interpret them. This is a highly satisfactory evolutionary sequence; but whatever taxonomic treatment one adopts for a situation of this kind is arbitrary and, at best, partially unsatisfactory. No panacea can settle the taxonomic treatment of borderline individuals or populations; it remains a question of judgment as to what will be the most generally convenient or, frequently, merely the least inconvenient, treatment.

In summary, the positive data of paleontology, covering the last 500,000,000 years, do not support any of the mystical theories regarding evolution, including orthogenesis; nor do known data support saltatorial theories of evolution. At any given moment, gaps in the paleontological record could represent either failure of discovery or a real nonexistence of any intermediate form; but the steady progress in filling previous gaps makes the second alternative

seem much the less probable. On the other hand, the positive data of paleontology fit in beautifully with those of population genetics (*e.g.*, Dobzhansky and Wright) and modern systematics and biogeography (*e.g.*, Mayr, 1942) into the unified modern or synthetic concept of the mechanism of evolution.

So far we have considered the record from the early Cambrian to the present time. Is it possible to say anything of scientific value concerning Precambrian life? We are on extremely uncertain ground here, but even speculation, if honestly labelled as such, is legitimate. From the beginning of the Cambrian to the present time, the prevailing evolutionary process has been diversification within existing phyla. The fundamental evolutionary deployment which formed the various phyla must have taken place in Precambrian time. However, the relevant positive evidence is extraordinarily skimpy: a few late Precambrian fossils, and indirect evidence for living material of some kind in early Precambrian rocks. Thus paleontology can still make no positive choice, for this earlier period, between rapid evolutionary deployment and slow evolution during an extraordinarily long period of time.

Wherever we do have positive paleontological evidence, the picture is of the most extreme gradualism, in other words, Lyell's uniformitarianism. The data of geology and paleontology, generally speaking, still fit with Hutton's (1788) famous dictum, extraordinarily prescient for its time, "we find no vestige of a beginning,—no prospect of an end."

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SOME NATURALLY OCCURRING ANTIBIOTIC POLYACETYLENES*

By MARJORIE ANCHEL**

During the past 30 years, the chemistry of acetylenic compounds has been investigated extensively, and a great many polyacetylenic compounds have been synthesized. Several volumes in which the chemistry of acetylene and acetylenic hydrocarbons is dealt with, have appeared,[1,2,3] and more recently the chemistry of acetylenic alcohols and acids has been reviewed in an excellent monograph.[4]

Up to a few years ago, however, there were almost no reports of naturally occurring polyacetylenes. Only three such compounds were described before 1950. In 1935, the isolation of the methyl ester of a ten-carbon polyacetylenic acid from *Lachnophyllum gossypinum* Bge. (Compositae) was reported by the Russian chemists, Wiljams, Smirnov, and Goljmov,[5] and in 1940, Castille[6] proposed a diacetylenic grouping in his formula for the 18-carbon compound, erythrogenic acid, isolated from the tree *Ongokea klaineana* Pierre, (Olacaceae) in 1937, by Steger and Van Loon.[7] In 1941 Sörensen and Stene described another polyacetylenic ester isolated from *Matricaria inodora* (Compositae).[8] This had the same carbon chain as lachnophyllum ester, but was more unsaturated.

In 1949, in the course of investigations made at the New York Botanical Garden, of antibiotic compounds produced by basidiomycetes, it was observed that the antibiotic activity of certain culture liquids was associated with compounds which had a characteristic and striking ultraviolet absorption spectrum.[9,10] These compounds proved to be polyacetylenes.[11] At about the same time, a series of papers appeared from the laboratory of N. A. Sörensen, in Norway, in which the isolation of polyacetylenes from several species of Compositae was described.[12,13,14] Only a short time later, the antibiotic compound, mycomycin, obtained from an actinomycete[15] was characterized as a polyacetylene.[16]

Within the last four years, there have been described, in all, about 25 naturally occurring polyacetylenes, about half of which were obtained from fungi, and half from higher plants. All of those from fungi were antibiotic. Those from higher plants apparently have not been systematically tested for antibiotic activity. Biological tests were reported only for the plant toxins, oenanthotoxin and cicutoxin, isolated from plants of the family Umbelliferae.[17,18,19] These plant toxins were characterized quite recently as polyacetylenes.[20] It seems likely that antibiotic activity is not confined solely to fungal polyacetylenes and, further, that polyacetylenic compounds which have little or no antibiotic activity must occur also as products of fungal metabolism. The fact that all those so far isolated from fungi are antibiotic may be explained by the circumstance that they were obtained as the result of screening procedures based on antibiotic activity. Since polyacetylenes, like polyethylenes, can be recognized by the characteristic spacing of their absorption maxima,[21,22] it may be possible to screen culture liquids by this method, to spot those polyacetylenes which are not antibiotic.

The compounds described below all belong to the group of antibiotic polyacetylenes. Structural relationships between these and other naturally-occurring polyacetylenes will be discussed, as far as they are known, and biological activity will be touched on, where such information is available. Nemotin and nemotinic acid,

*This paper was presented at a meeting of the Section on April 6, 1954.

**Research Associate, New York Botanical Garden, Bronx Park, New York, N.Y.

the first of the polyacetylenes isolated from basidiomycete culture liquids, have almost identical ultraviolet absorption spectra, but differ from each other both in respect to their antibacterial and antifungal spectra, and in their stability to alkali.[9,10] Nemotinic acid is essentially unchanged, under conditions that result in extensive modification of nemotin, as reflected in its absorption spectrum.[9,10] These changes are quite similar to those observed for mycomycin (under somewhat more rigorous conditions)[16,23] and it is believed that the change nemotin → nemotin A (the compound formed by alkali treatment of nemotin) may represent an allene → acetylene shift, similar to that of mycomycin → isomycomycin.[16,23]

Two other polyacetylenes isolated from basidiomycetes, drosophilin C, and drosophilin D,[24,25] undergo this type of spectrophotometric change on treatment with alkali.[25]

Neither the nemotins nor the drosophilins were obtained crystalline, owing to their rapid polymerization when dry, or even in concentrated solution. Two polyacetylenes obtained from the basidiomycete, *Clitocybe diatreta*[11] proved to be more stable. The first of these compounds was characterized as having one of the formulae I or II.[26]

$$HOOC.CH = CH.C \equiv C.C \equiv C.CONH_2$$

I

$$HOOC.C \equiv C.C \equiv CCH = CHCONH_2$$

II

These two possibilities probably could not be distinguished spectrophotometrically. However, Dr. E. R. H. Jones in Manchester who has determined the dissociation constants of a series of synthetic ethylenic and acetylenic acids, kindly offered to run such a determination on our compound, and fit it into the series. His results pointed to formula I as the correct one: The pK of our compound is 3.3; the pK of $CH_3-C\equiv C-CH=CH-COOH$ is 3.5, and that of $CH_3CH=CH-C\equiv C-COOH$ is 2.5. The compound is thus 7–carbamoyl–2–heptene–4,6–diynoic acid.

Names of biological products are frequently derived from the name of the producing organism. Thus the compound just described might be named from *Clitocybe*, or from *diatreta*. It might be useful, in the case of naturally-occurring polyacetylenic compounds, to earmark them with the -yne ending indicative of the triple bond. Accordingly, it is proposed to refer this first polyacetylene from *Clitocybe diatreta* as "diatretyne 1."

The second polyacetylene from *Clitocybe diatreta*, diatretyne 2, has a more extensive conjugated system, according to its ultraviolet absorption spectrum, which places it in the class of entriynes.[11] This compound, like diatretyne 1, is acidic, and contains nitrogen.

Another crystalline antibiotic polyacetylene, which was isolated from the basidiomycete *Agrocybe dura*,[27] has been characterized as having a triyne system of unsaturation, conjugated to a carbamoyl group.[11,28] This compound, agrocybin,* differs from those previously described, in that it apparently occurs in the culture liquid at least partly in a different form from that in which it is isolated, probably in a bound form, from which it is freed when the culture liquid is boiled.[27]

The same phenomenon was observed in culture liquids of *Polyporus biformis*.[29,30] Here, one antibiotic polyacetylene originally called "biformin"[29,30] and hereafter referred to as "biformyne 1" in accordance with the nomenclature proposed above, occurs "free" and can be extracted from the culture liquid directly with organic solvents. A second compound, biformyne 2, is extractable only after the culture liquid is boiled.[30]

Biformyne 1 is a 9-carbon glycol, which according to its absorption spectrum, con-

*According to a recent communication from E. R. H. Jones, agrocybin also possesses a terminal hydroxyl group.

TABLE 1

Test Organism	Minimum Inhibitory Concentration (Mg. per ml.)					
	nemotinic acid[10]	nemotin[10]	nemotin A[10]	drosophilin C[25]	drosophilin calk.[25]	biformyne 1[29,30]
Bacillus mycoides	250	31	31	13	112	63
Bacillus subtilis	0.25	0.06	4	3	7	0.125
Escherichia coli	125	31	250	26	54	2
Klebsiella pneumoniae	250	31	250	13	26	2
Mycobacterium pneumoniae	4	1	31	13	26	0.5
Pseudomonas aeruginosa	250	250	250	13	26	63
Staphylococcus aureus	1	2	2	6	112	1
Aspergillus niger	125	4	–	–	–	1
Chaetomium globosum	>250	4	–	–	–	1
Gliomastix convoluta	>250	16	–	–	–	4
Memnoniella echinata	125	0.5	–	–	–	2
Myrothecium verrucaria	250	4	–	–	–	63
Penicillium notatum	31	0.3	–	–	–	2
Phycomyces blakesleeanus	250	4	–	–	–	4
Saccharomyces cerevisiae	16	0.06	–	–	–	2
Stemphylium consortiale	250	16	–	–	–	1
Trichophyton mentagrophytes	64	4	–	–	–	0.5

tains two double bonds and two triple bonds in conjugation.[30] The position of the bonds has not been determined, but two possibilities exist:

$$-C{=}C.C{\equiv}.C{\equiv}.C{=}C- \quad \text{and}$$

$$-C{\equiv}C.C{\equiv}C.C{=}C.C{=}C-$$

The positions of the hydroxyl groups are also as yet undetermined.

Biformyne 2 can be reduced catalytically to a compound of molecular formula $C_{10}H_{20}O_2$. This compound is not acidic, and the functions of the oxygen atoms are still to be determined. The ultraviolet absorption spectrum of biformyne 2 is very similar to that of biformyne 1, so that the unsaturated systems of the two compounds are probably similar:

Maxima (Wave-length in mμ)

Biformyne 1 240-245 (infl.) 259 274 291 310

Biformyne 2 239 249 263 274 290 310

Both biformyne 1 and biformyne 2 exhibit the same behavior on treatment with alkali. This reaction consists of a slow change in the ultraviolet absorption spectrum, complete only after eight or nine days at pH 10 and 37°, resulting in the production of new absorption maxima at around 278 mμ and 291 mμ, which have extinction coefficients about ten times as high as the original (low)* values for those of biformynes 1 and 2.[30] This is apparently a different type of conversion from that obtained with nemotin and the drosophilins.

Of the biological properties of polyacetylenes, very little is known. As mentioned above, the compounds oenanthotoxin and cicutoxin, responsible for the toxicity of the higher plants, *Oenanthe crocata* and *Cicuta virosa*, notorious as stock poisons, were characterized recently as polyacetylenes.[20] Isolated tests carried out with some of the antibiotic polyacetylenes from basidiomycetes, suggest that these are quite toxic. Nemotinic acid had an acute

*The reason for the low extinction coefficients of these compounds is not understood. The possibility of the presence of sufficient impurity to account for the low values has not yet been rigidly excluded but, on the basis of other data, it seems unlikely.

TABLE 2

NATURALLY-OCCURRING POLYACETYLENES

C_8	agrocybin	$H_3CC{\equiv}CC{\equiv}CC{\equiv}CCONH_2$*	Basidiomycete (Agariacaceae)	11,27,28
	diatretyne 1	$HOOCCH{=}CHC{\equiv}CC{\equiv}CCONH_2$		11,27
C_9	biformyne 1	diendiyne (?) glycol	Basidiomycete (Polyporaceae)	30
C_{10}	lachnophyllum ester	$CH_3CH_2CH_2C{\equiv}CC{\equiv}CCH{=}CHCOOCH_3$	Dicotyledoneae (Compositae)	5, 32
	matricaria ester	$CH_3CH{=}CHC{\equiv}CC{\equiv}CCH{=}CHCOOCH_3$		8
	dehydromatricaria ester	$CH_3C{\equiv}CC{\equiv}CC{\equiv}CCH{=}CHCOOCH_3$		13
	α,β—dihydromatricaria ester	$CH_3C{\equiv}CC{\equiv}CC{\equiv}CCH_2CH_2COOCH_3$		33
C_{11}	nemotin	endiyne, (allene?)	Basidiomycete (Polyporaceae)	11
C_{12}	1, 11-dodeca-diene-3, 5, 7, 9, tetrayne-	$H_2C{=}CHC{\equiv}CC{\equiv}CC{\equiv}CC{\equiv}CCH{=}CH_2$	Dicotyledoneae (Compositae)	34
		$C_{12}H_{10}O$, (an entriyne, ketone)		13
C_{13}	1,3,5,11-trideca-tetraene-7,9-diyne	$CH_3CH{=}CHC{\equiv}CC{\equiv}CCH{=}CHCH{=}CHCH{=}CH_2$	Dicotyledoneae (Compositae)	34
	mycomycin	$HC{\equiv}CC{\equiv}CCH{=}C{=}CHCH{=}CHCH{=}CHCH_2COOH$	Actinomycete	16
C_{17}	oenanthotoxin	triendiyne, glycol	Dicotyledoneae (Umbelliferae)	20
	circutoxin	" "		20
C_{18}	erythrogenic acid	$CH_2CH(CH_2)_4C{\equiv}CC{\equiv}C(CH_2)_7COOH$	Dicotyledoneae (Olacaceae)	6,35
		$C_6H_5{-}C{\equiv}CC{\equiv}CCH{=}CHCH_2OCOCH_3$	Dicotyledoneae (Compositae)	34
		$C_6H_5{-}C{\equiv}CC{\equiv}CC{\equiv}CCH{=}CHCH{=}CHCH_3$	Dicotyledoneae (Compositae)	34
	bolekic acid	endiyne	Dicotyledoheae (Olacaceae)	22,35

*According to a recent communication from E.R.H. Jones, Agrocybin also possesses a terminal hydroxyl group.

toxicity of LD_{50} = 125 mg. per kilo, when injected intravenously into mice,[16] while the LD_{50} for agrocybin under the same conditions was less than 6 mg. per kilo.[27] The toxicity of mycomycin, however, was reported to be low.[15]

Microbiological assays with the basidiomycete polyacetylenes suggest that the antibiotic activity is not in the nature of a general toxicity, but is rather specific. Some of the data are given in TABLE 1.

It is apparent from this table that the ratios of the activity against certain organisms frequently differ considerably for the various compounds. While nemotin is only slightly more potent than nemotinic acid against most of the bacteria, it shows a very much greater activity than nemotinic acid against the fungi. Nemotin A and drosophilin Calk., the "alkali isomerization products" of nemotin and drosophilin C, respectively, have spectra which are independent of those of the parent compounds, but the compounds are of a somewhat lower order of activity. The same is true for isomycomycin.[23]

Conspicuous in this table are the relatively high activities against *Mycobacterium smegma*. These activities are, in general, of the same order as the activities against *Staphylococcus aureus*. This is not usually true for other antibiotic compounds, which are generally more active against *Staph. aureus* than against mycobacteria.

Other antibiotic compounds which are polyacetylenic, according to their absorption spectra, are the quadrifidins. These compounds also are reported to have considerable activity against *Mycobacterium tuberculosis*.[32]

The polyacetylenic compounds isolated from natural sources to date, are considerable in number, and varied in respect to chain lengths, unsaturated systems, and functional groupings. In TABLE 2, the relevant data are given to illustrate this point.

Polyacetylenes have thus been isolated from higher plants, from higher fungi, and from an actinomycete. The question naturally arises as to the possible role of these compounds in the metabolism of living organisms, a question about which, so far, nothing is known. Since a wide variety of polyacetylenic compounds, both synthetic and natural are now available, metabolic studies would seem to be indicated.

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*SECTION OF MATHEMATICS AND ENGINEERING**

PHENOMENON OF INTERACTION BETWEEN ELECTRIC AND MAGNETIC FIELDS**

By OLEG YADOFF***

A preceding paper presented to this Academy also dealt with the phenomenon of interaction between electric and magnetic fields.**** I should like to remind you now that this interaction consists of the change in electroconductivity of any metal or carbon conductor suspended in an atmospheric space in which adequately intense forces of electric charges were manifestly evidenced. According to this effect the electroconductivity of any metal conductors increased while it decreased for all carbon conductors.

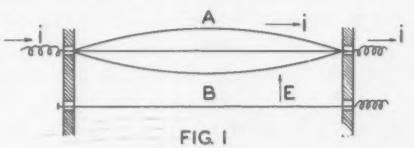

FIG. 1

FIGURE 1. Effect of the influence of the electric field *A* on current *i* in the case of two parallel wires; the effect of rotational oscillations of conductor *A* influenced by *B* is shadowed.

Today I have the honor of presenting some peculiarities of another effect. This second effect derives, we should say, from the first, although from the viewpoint of physics it is endowed with a completely independent aspect. There are two effects:

(1) Let us imagine two conductors, *A* and *B*, as depicted in FIGURE 1. We channel any current *i* through the conductor *A* (direct or alternating) originating either from a battery or from a network of 110 volts and 60 cycles, while we shall connect to the conductor *B* a pole from any high voltage source. It is sufficient for this purpose to connect with a positive or negative pole of any electrostatic machine; the second pole of the machine is either completely superfluous or connected to the ground.

(2) By changing in conductor *A* the electric current *i*, and the electric field *E*, around the conductor *B* we can easily calculate the relation between *i* and *E* when the conductor *A* suddenly acquires the regular rotational oscillations around its axis.

For a more accurate definition of the phenomenon a device was constructed as in FIGURE 2.

Within a rather spacious cylindrical body *C* (for instance, one meter in diameter) made of a metallic sheet or screen, the conductor *A* is introduced in an atmospheric space so that there would be absolutely no contact between it and the cylinder *C*. Letting the current *i* pass through *A* and regulating this current with the help of ammeter Am. and rheostat Rh., we receive, by connecting contact *B*, the rotational oscillations of the conductor which acquires the form of an elongated cigar, as pictured in FIGURES 1 and 2. Modifying the forces of interaction between *i* and *E* we influence the appearance of its original aspect and we alter its visual appeal by transforming it into a vivid red, or a whitish blue, or purple.

The position as shown in FIGURE 2 is the most advantageous, since the power lines that derive from the interior wall of the cylindrical body *C* meet concentrically and precisely on the surface of conductor *A*, which occupies the position of a central axis. But the rotational phenomenon occurs also in all other cases, when the conductor

* The Section of Biology held a meeting on April 12, 1954 at which a paper entitled "Lysogeny" was read by Andre Lwoff. No abstract of this paper had been received at the time of publication.

** This paper was presented at a meeting of the Section on April 16, 1954.

*** Manhattan College, New York, N.Y.

**** YADOFF O. 1952. Influence of an electric field on an electric current in metallic or carbon conductors. Trans. N.Y. Acad. Sci. 14(4): 165-171.

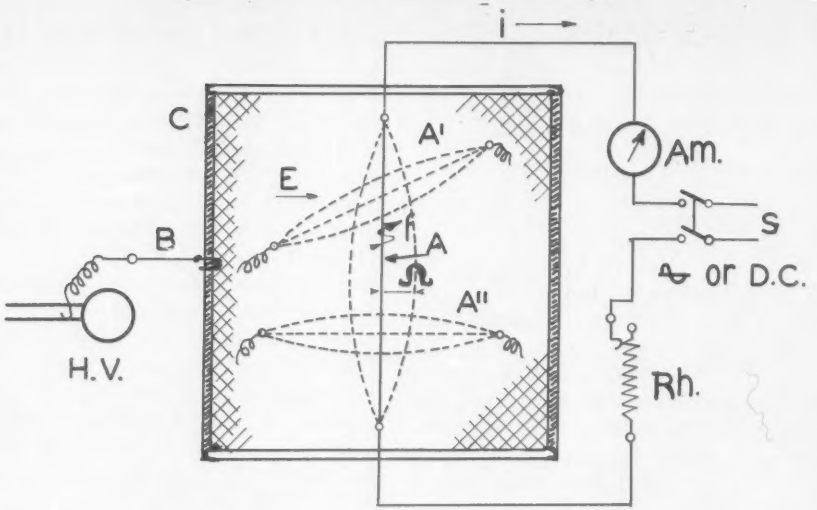

FIGURE 2. Diagrammatic representation of experiment in which conductor *A* fed by current *i* of an independent AC or DC source is influenced by the electric field *E* coming from the cylindrical body *C*, connected in *B* at a source of high voltage HV. Am. is ammeter for measuring increase in current, Rh. is rheostat. *S* is AC or DC. The representation of rotational oscillations of conductor *A* is shadowed. *A'* is the position in any oblique of the conductor and *A''* is in horizontal position. Ω is amplitude and *f* is frequency.

A, for instance, is thrown off center, or when it is in a reclining position *A'* as indicated by the dotted line, or when it is situated according to *A''* vertical in relation to wall *C* or, in other words, whenever it is parallel to the power lines of electric field *E*.

Amplitude Ω increases with the expansion of the conductor from warmth, but it follows the electric law precisely, depending on the intensity of current *i* and electric field *E*. Generally the amplitude increases with the increase of the current. The changes in frequency are more complex. They also depend on the strength of the current and electric field but increasing, first, along with the increase of the current, the frequency passes a definite maximum point and, thereafter, markedly decreases, coming down to zero. It should be mentioned that the frequency of oscillation is comparatively low and has no connection with the alternating source of the current such as, for instance, 60 cycles. When, in the above-explained installations, the interrelation between current *i* and field *E* reaches a particular point, the conductor oscillates rotationally with amplitudes and frequencies directly dependent of *i* and *E*. The oscillations begin while they are still in the initial color, at relatively low temperatures. When the current *i* reaches a certain intensity i_o (critical intensity) the effect disappears abruptly; the conductor *A* ceases to oscillate, turns to a vivid yellow and then breaks under the current overcharge. With low intensities of current *i* and a relatively high electric field *E*, the rotating wire *A* turns whitish, its color gradually resembling the emissions of phosphorescent bodies. When *E* is properly increased, it diffuses a bluish color, darker toward the center, and also a peculiar purple hue. These colors correspond to the appearance of the corona effect around the wire in the absence of current *i* and without oscillations of the conductor. We can also obtain a blue-purple color in the center zone of *A* which, in spreading toward the extremities, turns to

a normal, and then to a bright red, finally to an incandescent yellow. These observations were made during experiments conducted under normal atmospheric pressure. During tests, however, with a mixture of air and certain gases, interesting variations of the spectrum were obtained.

FIGURE 3 shows a photograph of a neat cigar-shaped circling conductor in a state of incandescence. A clear red at its center, it increases in brightness toward its extremities. This photograph was taken of an experimental cylindrical body in transparent plastic of 35 cm. in length and 12 cm. in diameter. The emitting electrode of field *E* is made of a metallic sheet or screen (or a metallic point, which is more visible, as we may see from the figure). The interior walls of the cylinder, which is supported by two rectangular insulating plastic end-plates, are either full or pierced to allow air to enter. The plastic cylindrical body is not indispensable; the effect is produced with all other materials as it is with pressure or, as we may see, simply when exposed to air under atmospheric pressure.

The oscillating effect of the wire is also produced in air drafts; we have been able to record speeds up to 1,000 feet per minute. The effect is also produced in more or less diluted gases and air as well as with gases and air under pressure. Tests have been made on gases by introducing other radon gases into air. Doctor Boris Pregel's tests have shown that the influence of the electric field is very significant when, for instance, a pole having a negative sign is connected to the metallic screen *B*, while a positive pole is connected to wire *A* during the life period of the radon. With our device and with the realization of the interaction between *i* and *E*, Pregel's tests are particularly interesting since the radon also participates in the interaction. Doctor N. V. Feodoroff conducted a series of similar experiments with different gases such Co, Co_2, So_2.

These rotating whirls are not an individual but a general phenomenon. The emanation of electrons releases a part of the electrons in view of the presence of radon with a speed which approaches the speed of light, and thus the lumination can be explained. The major part of the electrons, however, rotates with a speed that approaches the speed of the rotation of the conductor *A*. As soon as the rotation speed of the conductor *A* is changed, a difference is instantaneously produced between the speed of the electrons and that of the conductor. That difference easily becomes supersonic. In other words, a certain electron rotates at supersonic speed in relation to the conductor. At the same time the electron develops acoustic waves of various ranges producing musical sounds. I suggested that these electrons be named

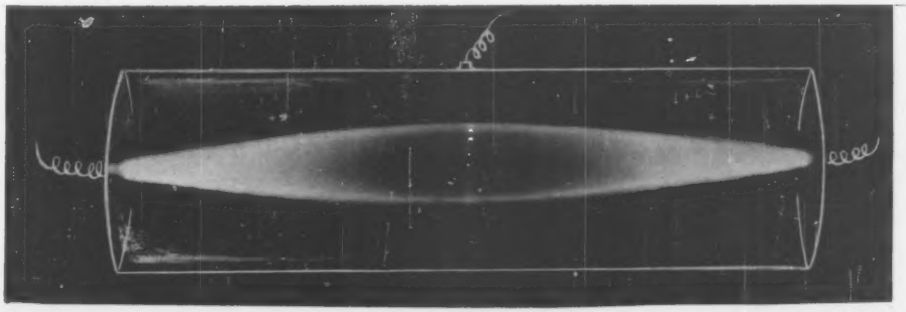

FIGURE 3. Photographic representation of a circling conductor in a state of incandescence.

"singing electrons." Also of interest is the fact that certain *A* frequencies give birth to scales of sonorous diatonic waves.

Deep tones are especially heard with sudden frequency variations of current *i* or field *E*, while in some other cases, stationary waves are heard. Certain tones are amplified by inserting between *A* and *B* a paper or a taut leather membrane; paper, leather, silk, or any other similar insulating matter does not disrupt the rotational oscillation effect, while certain sounds are thereby amplified. If, however, instead of being secured at its extremities, the conductor rests on ball-bearing insulators, it gyrates as would any motor shaft, so that with the realization of a system of conductors connected in series or in parallel, and conveniently disposed around an axis, we may evolve a system giving thought to a new principle for an electric motor. The rotational-oscillations phenomenon is observed in stationary air under normal atmospheric pressure and also in diluted or even compressed air; we have also verified its presence in air drafts of high velocities reaching 1000 feet per minute. The many material particles carried by the air drafts do not nullify or modify the rotations. Furthermore, we observed oscillations of *A* in liquids considered good dielectric insulators, such as mineral and vegetable oils. Electroconvective whirls appeared around the conductor, then rotations absolutely analogous with those produced in air or gas media. We must add, however, that rotational oscillations sometimes divide the conductor into multiple harmonics in particular cases of specific relation between *i* and *E*. FIGURE 4 outlines the diagrammatical representatives of oscillating rotational conductors, one harmonic and one double harmonic, with indications of division into sound waves. FIGURE 5 shows a regular double harmonic.

Conclusions and Remarks for Discussion

We conclude by stating that the described effect results from phenomena generally reproducible under all circumstances with faithful accuracy. To what factors, however, may we attribute this phenomena? We are certain that free charges of the same sign guided by the electric field *E* move within the space included between conductor *A* and electrode *B*. In other words, the space found between *A* and *B* is in a state of electrification and not in a state of classic ionization. After these free charges proceed – impelled by means of a rather complex mechanism which we shall discuss later – they converge concentric-

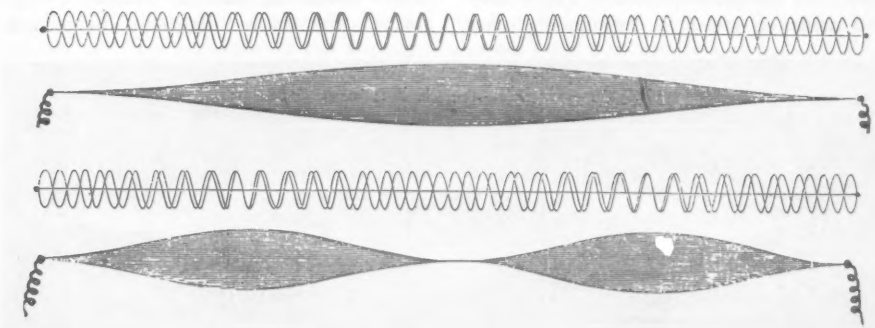

FIGURE 4. Diagrammatic representation of an oscillating rotational conductor, one harmonic and one double harmonic, with indication of division into sound waves.

ally toward the conductor, striking it with elastic blows of a certain wave length.

We have shown that the described effect is essentially related to current i in conductor A and to the field E, produced either by a wire B located in the immediate vicinity, or by any emission electrode of the field, or by a cylindrical body. We have explained that the effect is reproduced only beyond a certain intensity of current i_1 and is equally limited by another certain intensity i_2; therefore, the effect occurs within the current interval between i_1, and i_2. The effect is thus produced for a tension of a well-defined field E, superior to E_o, which is the value of the critical field as determined above. Thus, a direct relation between current i and emitting field E exists. However, the current i flowing through the conductor is directly proportional to the accompanying magnetic field H, and it follows that the phenomenon of rotational oscillations is essentially dependent on two factors: magnetic field H and electric field E. The interaction between these two fields characterize the amplitude and frequency of these oscillations. A weak H does not react sufficiently to the forces created by E, and rotational oscillations do not appear. By contrast, with a strong H, all electronic charges are deflected from A and projected toward the exterior, in correlation with the sudden elimination of the phenomenon; at that particular moment, the conductor ceases to rotate and turns to a vivid yellow incandescence.

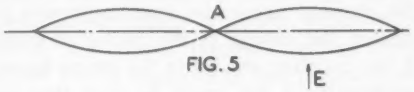

FIGURE 5. Double harmonic of rotational oscillations.

The variations in amplitude and frequency corroborate the hypothesis of interaction between the electric field and the magnetic field. We are pursuing certain additional studies in the subject which should ultimately facilitate better comprehension of the above-described occurrences.

SECTION OF PSYCHOLOGY

VERBAL FACTORS IN PROBLEM SOLVING BEHAVIOR*

By HOWARD H. KENDLER**

Practically all psychologists who have at times concerned themselves with human problem-solving behavior have recognized the importance of verbal factors in such activity. This recognition is merely the first step toward the rather distant goal of understanding the means by which language influences reasoning behavior. The aim of the present paper is to take one more step —or more appropriately a half step—towards the above-mentioned goal. This paper seeks to suggest a conceptual framework by which the relationship between verbal factors and problem-solving behavior can be formalized and subjected to systematic empirical investigations.

Our proposed conception is neither novel nor overly ambitious. It is consistent with the neobehavioristic conception of behavior and is indebted to some of Hull's specific ideas concerning the integration of complex behavior patterns.[5] Our conception, although independent of, bears resemblance to those of Osgood,[10] Cofer,[3] and others. Our conception is modest in that it desires merely to give order to some experimental data, and forsakes for the present and immediate future the task of providing an understanding of reasoning behavior as it occurs in "real life" situations.

How are we to consider language behavior? According to Watson[11,12] words were merely substitute stimuli for physical objects and situations. Hull[5] later integrated some ideas inherent in Watson's formulation within his systematic account of behavior. Hull distinguished between instrumental and cue-producing responses. An instrumental act, such as the depressing of a bar by a rat in a Skinner Box, or pressure on a brake pedal exerted by a driver was one that produced an immediate change in the external environment. Contrasted with this type of response was cue-producing behavior, or what Hull labelled the "pure-stimulus act." Rather than affecting the external environment these responses would provide a cue for another response. Example of response-produced cues would be the implicit verbalizations of a human counting his change after making a purchase. If the counting results in the correct figure the overt response of putting the change in the pocket is made. If the counting results in the wrong figure, especially if the count be less than the correct figure, the overt response of informing the sales person is made. It should be mentioned that the ability to make cue-producing responses is not restricted to verbal organisms. For example, the white rat, according to the neobehaviorists, is capable of making anticipatory-goal responses which produce cues, making possible behavior that otherwise would not occur.[6,7,8]

Let us now turn our attention to how the concept of a response-produced cue affects problem-solving behavior. A good example is provided by an experiment[3] which sought to demonstrate that, by increasing the availability of a response-produced verbal cue, the probability of problem solution also would be increased. The problem used was Guetzkow's[4] group form of the Maier two-string problem. This problem requires the tieing together of two strings suspended from the ceiling. The lengths of the strings and the distance between were

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** Department of Psychology, Graduate College of Arts and Science and University College of Arts and Science, New York University, New York, N.Y.

such as to prevent the subject from grasping one and walking to the other and then tieing them together. One possible solution is to tie a weight to one string and set it in motion, so that it swings like a pendulum and then, while holding the other string, walk towards the swinging pendulum and grasp it while in motion and then tie the strings together.

One group of male subjects was required to learn eight lists of five words, one list including the words *rope, swing,* and *pendulum.* The other group had essentially the same experience except for the learning of these three words within a common list. The results indicated that the memorizing of these three words within one list increased the percentage of problem solutions. According to our analysis, which is essentially similar to that offered by Cofer[3] the stimulus of the string had by previous experience a strong tendency to evoke the verbal response *string.* This covert verbal response in turn produced an implicit cue of the word *string* or some other symbolic representation of a string. This latter implicit cue had a certain tendency to evoke a verbal or symbolic response of *rope* which in turn would serve as a cue for either or both of the verbal responses of *swing* and *pendulum.* These latter verbalizations would have certain probabilities of evoking the overt problem-solving act. A summary of our analysis would be simply that by increasing the tendency of the word *string* to evoke the verbal response of *swing* or *pendulum* the probability of the problem solution was increased.

The above description, it will be recognized, is greatly simplified. The chaining of successive S-R associations are probably in most cases, if not in all, more complex than the above-described uncomplicated four link chain. The sequence of the chain probably varies from individual to individual. Each link in the chain involves some degree of patterning; *i.e.,* the tendency for any implicit symbolic cue to evoke a particular symbolic or overt response will depend, to some extent, upon the nature of the internal and external environment coexisting with the implicit symbolic cue.

It should be recognized that increasing the tendency for the word *rope* to evoke the words *swing* and *pendulum* does not guarantee problem solution. As had already been mentioned, an ordered sequence of associations is required for problem solution. No matter how strong the tendency is for the word *rope* to evoke the words *swing* and *pendulum,* problem solution will not be facilitated for the subject if the implicit verbal cue of *swing* fails to evoke the verbal response of *rope,* or if the word *pendulum* evokes a verbal or symbolic response of a weight on a rigid steel or wooden bar. To summarize this point, the solution of the type of problem just described requires a rather lengthy and complex sequence of S-R associations. The probability of problem solution will be increased by increasing the strength of some of the appropriate associations within the chain, but will not be guaranteed unless all essential associations are strengthened to the necessary degree.

A somewhat simpler situation that lends itself to more systematic hypotheses about the cue properties of verbal responses is the conventional card-sorting tests.[1] These tests permit sorting of cards containing different-colored geometrical figures in a variety of ways. Kendler and D'Amato[9] in an unpublished study used cards on which appeared geometrical figures varying in shape and color. Half of the cards had rectilinear shapes while the remainder had curvilinear shapes. Unrelated to this difference was the difference between the "colors" of the figures. Half were chromatic while the remaining half were achromatic. Consequently the cards could be sorted into

two categories in two ways, *i.e.*, on the basis of shape, or on the basis of "color."

These investigators assumed that card-sorting behavior on any one trial consisted of a sequence of two successive S-R associations. According to this formulation the stimulus component of the first association would represent the test cards, while the response would refer to implicit verbal or symbolic responses made to them. The stimulus of the second association would represent the cue produced by the preceding implicit response, while the response would be the overt card-sorting behavior. The specific hypothesis tested in this study was that the availability of the appropriate symbolic cues (the stimulus of the second association), even though these cues might be connected to the "wrong" sorting response, would facilitate concept formation.

This hypothesis was applied to a situation involving the learning of successive concepts in a card-sorting test. For one group (reversal shift) the second concept to be learned was the reverse of the first concept, *i.e.*, the cues were reversed so that the subject was required to sort the cards in a fashion opposite to that demanded initially. An example of a reversal shift would involve a subject sorting the cards into two categories on the basis of shape (rectilinear versus curvilinear) and then shift his sorting responses so that the rectilinear shapes would then be placed where the curvilinear shapes had been placed previously and vice versa. For the other group (nonreversal shift) the second concept was unrelated to the first concept in the sense that the basis of the correct sorting was shifted from one stimulus dimension to an entirely different one. An example of such a nonreversal shift would involve sorting of the cards by a subject initially in terms of shape, and then requiring the subject to shift his sorting basis to color.

The prediction made was that the reversal shift would occur at a more rapid rate than would the nonreversal shift. This action would follow from our analysis because at the completion of the learning of the first concept, the implicit symbolic cues appropriate to the second concept would be present for the subjects in the reversal group; the cues would merely be connected to the "wrong" sorting responses. There is, however, another way of analyzing the relationship between a reversal and a nonreversal shift. Buss[2] reported, in an experimental situation somewhat similar to the one just described, that a reversal shift occurred at a more rapid rate than did a nonreversal shift. His explanation, however, did not involve a mediational process between the stimulus and the response. According to Buss, the nonreversal group would receive fortuitous partial reinforcement of their initially acquired concept while they were learning the second concept. For example, in the previously described experimental situation of Kendler and D'Amato, if the subjects in the nonreversal group persisted in responding to shape during the learning of their second concept (color), they would nevertheless be correct 50 per cent of the time. This partial reinforcement, according to Buss, would serve to maintain the shape discrimination and hence retard the learning of the "color" concept. The reversal shift group, on the other hand, would receive no reinforcement of the discrimination learned previously while learning their second concept, *i.e.*, the previously correct responses of this group would be 100 per cent nonreinforced.

As a result of Buss's findings and interpretation, Kendler and D'Amato sought to discover whether a reversal shift would be more rapid than a nonreversal shift in an experimental situation in which the effects of partial reinforcement would be initially eliminated. According to the analysis of Kendler and D'Amato, the control of partial reinforcement effects should not affect the

superiority of a reversal over a nonreversal shift, since the important factor is the presence of the appropriate symbolic cues for the reversal group when the learning of the second concept is initiated. This condition should not be changed by the elimination of the effects of partial reinforcement for the nonreversal group.

The results of Kendler and D'Amato were consistent with their hypothesis. The superiority of a reversal shift over a nonreversal shift was discovered to be independent of the presence or absence of any partial reinforcement effects from previously learned concepts. Such results emphasized the importance of response-produced cues in human concept formation. In the reversal group, the appropriate symbolic cue was present at the time of the shift and hence became rapidly connected to the newly required sorting response. These results, at least to this author, demonstrate the superiority, in dealing with concept formation and problem-solving behavior, of an S-R approach involving a mediational process over an S-R approach which involves no such process.

The identification of language with the concept of response-produced stimulation has interesting theoretical implications. The result, in terms of an S-R orientation, is to extend the concept of a stimulus from a directly observable concept to an inferred theoretical construct. The concept of a stimulus therefore acquires features in common with the psychological or behavioral field of the Gestalt psychologist. There is however, a basic difference in orientation. Whereas the Gestalt-oriented psychologist has been content to define the psychological or behavioral field in terms of introspective reports, the S-R psychologist is compelled, because of behavioristic tradition, to define the concept of response-produced stimulus in terms of experimentally manipulative variables. In the experiment of Kendler and D'Amato, it will be recalled, the presence of the appropriate symbolic cue was defined, not in terms of any introspective reports but rather in terms of the experimental procedure of requiring the subjects to learn the first concept prior to being shifted to the second concept.

Up to this point, verbalizations have been viewed as covert stimuli and responses. It should be clearly understood, however, that verbalizations have a greater function than merely to serve as a substitute for a physical stimulus. Verbal cues may not only serve as a substitute for a specific physical stimulus but also for a relationship between physical stimuli, or for a relationship between relationships. Frequently humans are in problem-solving situations in which verbal or symbolic cues representing relationships between physical stimuli are required before problem solution can occur.

An unpublished study by Kendler and Vineberg[9] experimentally demonstrates this point. These investigators sought to determine the influence the learning of simple concepts (concepts based upon one stimulus attribute) had upon the learning of compound concepts which involved combinations of simple concepts.

The experimental procedure involved the use of a card-sorting test patterned after the Wisconsin Card Sorting Test[1] and similar to the one used by Kendler and D'Amato.[9] The test involved the use of 32 response cards which varied in terms of four forms (circle, crescent, square, and triangle), and four "colors" (black, gray, yellow, and orange), and two sizes. These response cards could be sorted into two categories represented by these two stimulus cards in four different ways. The basis of such sorting would involve four simple concepts; shape, color, size, and "part-whole." The shape concept involved sorting rectilinear figures (squares and triangles) separately from curvilinear figures (circle and crescent). The two "color" concepts were chromatic colors (yellow and orange) and

achromatic "colors" (black and gray). The size concepts involved large and small figures. The "part-whole" concept required the sorting of part figures (crescent and triangles) from whole figures (circle and square). The rationale of this last concept was that a crescent is physically a part of a circle, while a triangle is physically a part of a square. This card-sorting test also permitted the sorting of the cards on the basis of two concepts simultaneously. For example the compound concept of size and shape would result in four sorting categories: small rectilinear shapes, large rectilinear shapes, small curvilinear shapes, and large curvilinear shapes.

The data which are most relevant to the problems under consideration stem from the results of two experimental groups, both of which learned a compound concept, composed of previously learned simple concepts. Group 1 initially learned the shape concept, then the size concept, and then the compound size-shape concept. Group 2 initially learned the color concept, then the "part-whole" concept, and then the compound color-"part-whole" concept. The results indicated that all the subjects in Group 1 learned the compound concept requiring a mean number of trials of 23. Only 40 per cent of the subjects in Group 2 were able to learn their compound concept within the allotted number of trials (192). Those subjects who were able to master the color-"part-whole" compound concept required a mean of 78 trials.

These results indicate that the mastery of the simple concepts does not necessarily insure the solution of the compound concept. If subjects can learn the simple concepts, why cannot they learn the compound concept which is a mere combination of the two simple concepts? The answer to this question lies in understanding what responses are learned when a subject masters a simple concept. It should be remembered that when a subject was learning a simple concept, he was required to sort the response cards into only two categories. It would be possible to sort the cards appropriately without discovering the rationale for the correct sorting procedure. For example, in solving the "part-whole" concept, an *S* by rote memory could learn that he should separate all crescents and triangles from all circles and squares. Although such behavior results in the successful acquisition of the simple concepts, it fails to provide those verbal cues (part figures versus whole figures) which represent the important relationships between the various figures and facilitates the acquisition of the test concepts. The experimental results, as well as the introspective reports, suggest that whereas the subjects in Group 1 learned the appropriate symbolic responses when learning their simple concepts, the same condition did not prevail for the subjects in Group 2. It seemed that for most subjects the relationship of part to whole between a triangle and square was not verbalized or symbolized by most of the subjects in Group 2. Their failure to be able to represent symbolically the "part-whole" relationship between the triangle and the square prevented the necessary verbal cues from being transferred to the the learning of the compound concept.

In conclusion it may be well to summarize our paper by stating that we have sought to demonstrate the relationship which successful problem solution bears to the availability of appropriate verbalizations and their resulting implicit cues. The data that has been reported demonstrated that (1) by arranging a set of verbal response tendencies to a given word, one can increase the probability of problem solution; (2) the availability of the appropriate verbal cue will be related to the speed of problem solution; and (3) problem solution can be retarded or prevented if appropriate verbal cues, representing relationships between physical stimuli, are not available.

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INTERRACIAL CONTACT AND ATTITUDE CHANGE*

By DANIEL M. WILNER**

As time goes on, Negroes and whites are more and more finding themselves working, living, and pursuing their leisure side by side in close physical adjacency. In view of the marked past and still widely prevalent patterns of segregation, one wonders what effects the new proximity will have on the relations between the races. Will proximity intensify the already existing prejudices of members of the one race toward the other? Will it reduce prejudice? Or will it leave the level of prejudice unaffected?

Unfortunately, newspapers and popular-magazine accounts give us an unrepresentative sample of reports on Negro-white relationships in instances of close proximity. In the eight or ten relevant news stories I have seen in the past few months, all tell of some interracial difficulty that attends racial mixture. The trouble is that conflict is generally more newsworthy than good relations; none of the stories printed carried the headlines "No trouble today—or for the past six months—in Kingsboro Houses in Brooklyn—or in Rodger Young Village in Los Angeles."

What is the true situation? What does happen when Negroes and whites find themselves living side by side? In the study I am reporting, we attempted to get answers to some basic questions about race relations in mixed residential circumstances.*** We tried first to document the nature of the contacts that developed among members of the two races when they found themselves in close physical proximity, say in adjacent apartments or buildings. We also tried to determine the impact of these contacts on attitudes held by white residents toward Negroes.

Plan of the study. We modeled our design after some notable *ex post facto* designs in this field of study, namely those of Kramer,[1] Merton, West, and Jahoda,[2] Deutsch and Collins,[3] and the Research Branch of the United States Army Information and Education Service.[4] In these studies, white persons in residential or army settings were found living or working at varying distances from Negroes. Comparisons were made to see if differences in proximity to Negroes made any difference in the ethnic attitudes of the whites. This sort of design has several advantages. First, it focuses on an aspect of residential living arrangements that several studies have suggested are crucial for the development of friendly intergroup relations, *i.e.* physical proximity; and, second, it provides a methodological device for determining the consequences of close proximity by providing a control group without this factor. Thus any differences resulting between proximity groups can be attributed, if certain assumptions are met, to differences of physical or functional distance between the races and, of course, to the conditions that attend the difference of distance.

Sites of the present study. A careful search for possible study sites located four Negro-white public housing developments in four eastern cities that had the following general characteristics:

(1) They were at least 75 miles from the metropolitan New York area.

(2) Negro families were in the proportion fairly representative of Negro-white ratios in biracial projects throughout the country; in each project 10 per cent of the families were Negro.

(3) While there was considerable varia-

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** Research Center for Human Relations, New York University, New York, N.Y. Now at Department of Biostatistics, School of Hygiene and Public Health, Johns Hopkins University, Baltimore, Md.

*** The research was completed two years ago and was carried out at the Research Center for Human Relations by a research unit including Rosabelle Price Walkley and Stuart Cook. Funds supporting the study came from the Marshall Field Foundation.

tion in project layout, all buildings were at most two stories high.

(4a) Two of the projects had an integrated occupancy pattern: *i.e.*, Negro families lived in the same buildings with white residents, but as only 10 per cent were Negroes, many whites of course lived in all-white buildings.

(4b) Two of the projects had a building-segregated occupancy pattern, *i.e.* Negro and white families lived in separate buildings, but the buildings housing Negroes and whites were interspersed among one another.

This combination of particular occupancy patterns and the relatively small proportions of Negroes in each project made possible utilization of the research design already mentioned, for some white residents in each project lived in apartments relatively near Negro apartments, and other whites lived relatively farther away. This difference in distance from Negro apartments within a project constituted the major independent variable of the findings described in this report.

A few further facts about the projects may be of some interest. Two were in New England. They were: (a) in fairly large cities, but under 200,000 population; (b) of moderate rental ($50 to $60 average); (c) *new* (both 95 per cent occupied only about a year before the study); (d) of moderate size (200 and 300 families, respectively); and (e) almost completely occupied by veterans of World War II and their families, thus constituting a fairly homogenously young population including young children.

The two projects were chosen to be, as nearly as possible, matches for each other; the major difference was that the one (Project A) had the integrated, and the other (Project B) had the building-segregated occupancy pattern.

The other two projects were in a middle-Atlantic state. They were: (a) in very large cities (of more than 500,000 population); (b) of low rental ($30 to $40 average); (c) relatively old (both 95 per cent occupied at least six years before the study); (d) of large size (440 and 1000 families, respectively); and (e) largely populated by an older longer-resident group than the veterans of World War II, who were getting rental priority at the time of the study.

As in the preceding pair of projects, a major difference between them was occupancy pattern, the one (Project C) being integrated, and the other (Project D) building-segregated.*

Collecting the data. Data was collected by means of detailed interviews with samples of white residents living *near* and living *far* from Negro residents in the project.** In the integrated projects the "nears" lived in mixed buildings and the "fars" in all-white buildings. In the building-segregated projects the general principal of comparison was between white residents in buildings adjacent to Negro occupied buildings ("near") and those in buildings not directly adjacent ("far"); in one of these projects, several white buildings were included in the "near" sample which were in the same court as Negro-occupied buildings, even though not directly adjoining. All "near" and "far" designations were made before the interviewing was begun, and sampling was done randomly from large pools of "nears" and "fars." The number of respondents interviewed in each proximity group range from 58 "nears" in one project to 145 "fars" in another. Only housewives were interviewed.

Contact. How is interracial contact related to proximity? We asked each white respondent about her characteristic contacts with Negro tenants in the project; whether there was mutual greeting in chance

* The fact that these pairs of projects were deliberately chosen for similarity on all characteristics but occupancy patterns is irrelevant to the present report which concerns differences in the experiences of white persons living at various distances from Negroes. Details of these comparisons involving occupancy pattern may be found elsewhere (5,)(6).

** The interview schedule consisted of 86 questions and took from one and one half to two hours to administer.

encounters with Negro residents; whether she stopped to chat during such encounters; and whether she took part with Negro residents in such neighborly activities as visiting back and forth, helping one another out (baby sitting, *etc.*) doing things together (going to the store together, *etc.*). From the answers to these questions, which contained great detail regarding particular activities, we constructed a scale of contact ranging from "no contact" at one end, to "participation in neighborly activities" at the other.

In TABLE 1 we see how position on this scale is related to white residents' physical distance from Negro residents. In each project white housewives who lived near Negroes—in the mixed buildings in the integrated projects, and in *adjacent* buildings in the building-segregated projects—were more likely than those living farther away to experience the more intimate forms of contact with Negro tenants. Conversely fewer "nears" than "fars" reported having no contact at all—not even casual greeting during a chance encounter—with Negroes.*

Conversation. One measure of the nature of the contact between the races is the kind of conversation that takes place when contacts occur. The white housewives were asked what topics were discussed in typical conversations with Negroes in the project. As might be expected from differences in interracial contact already reported, a considerably larger proportion of "nears" in any project than the corresponding "fars" report talking about a given topic to their Negro neighbors. The list of topics mentioned by a third or more of the women living near Negroes is illuminating. They talked about schools, children, husbands, prices, the project in general, war, and the news. In two of the projects one quarter of the "nears" talked with Negro neighbors about how colored and whites get along.

Place of chance encounters. How does relative nearness between whites and Negroes make interracial contact more likely? A suggestion comes from the question, "Where do you ordinarily see or run into the colored people who live here?" The nature of the casual encounter situation is substantially different depending on physical distance from Negro tenants. A large majority of white persons, regardless of where they live in the project encounter a Negro on the streets of the project, while waiting for a bus, or while transacting business in the project office. But considerably more "nears" than "fars" report unplanned encounters at locations closely related to place of residence: the clothesline, the parking area, just outside the building, on the stairway of one's building (where there was a common stairway) and in a neighbor's apartment.

One way of looking at this finding is that those who live near Negroes are more likely to encounter them under conditions conducive to further acquaintance. On the other hand, for white residents living relatively far from Negroes the prime condition that makes for the development of more than mere recognition among the persons involved is normally lacking—namely, there is no great likelihood of recurring meetings with the same persons under circumstances conducive to conversation and to the discovery and development of common interests.

But living near Negroes does more. It also makes more likely *neighborly* contacts centering around certain necessary home activities. When we look at the diverse activities which constitute neighborly association, we find that the items which dis-

* In this table as well as in the others describing the substantive findings of the study, it will be observed that there are substantial differences among projects for any dependent variable discussed. Thus in TABLE 1 it can be seen that a far larger proportion of "nears" in Project A than in any other project report neighborly interaction with Negro residents. Conversely far more "fars" in Project C than in any other project report no contact at all with Negro residents. These project differences are attributable to a variety of factors, such as project architecture and the relative homogeneity and heterogeneity of project populations. Project differences are discussed elsewhere.6

tinguish best between proximity groups are: borrowing and lending, help during sickness, minding one another's children, help with shopping, and social visiting.

In other words, living relatively near Negroes makes it more likely that the white tenant will engage in such activities with Negroes—as well as with whites—as are necessary for comfortable living in the project.

Following are some comments which white women living near Negroes made about their contacts with Negro residents:

"When my husband was ill, the (Negro) girl next door was wonderful—sent in food and gave me money."

"At first when we moved in I would hear people say, 'What are colored doing here?' Now I see them running back and forth. We all sit out and visit in the summer regardless of color."

"If I invite neighbors in, I always invite the colored just as well—for TV, *etc.*"

It may be noted that, up to this point, except for the interracial character of the contacts involved, our findings do not differ in any essentials from those of Festinger, Schachter, and Back[7] in their description of the role of proximity in the development of friendly relations in racially homogeneous housing projects. We shall shortly turn to the interaction between contact and attitude and see what further consequences are generated by the fact that the parties to the contacts are of different races. First, however, let us consider the critical issue of the initial comparability of "nears" and "fars."

Initial comparability. No measurement of initial attitude of our respondents was feasible at the time they moved into the projects. But it is conceivable that every white resident moving in "near" Negroes had favorable attitudes toward Negroes to begin with, and those moving further away, less favorable attitudes. To understand the proximity-contact process fully, we must assess initial attitude by other means. Information of three sorts was used to check on the possibility that "nears" and

TABLE 1

PROXIMITY AND EXTENT OF CONTACT BETWEEN WHITE AND NEGRO WOMEN

Comparison of White Women Living Near Negroes with White Women Living Farther Away (by Projects)

*Level of contact with Negro residents:**	*Project A*		*Project B*		*Project C*		*Project D*	
	Near	*Far*	*Near*	*Far*	*Near*	*Far*	*Near*	*Far*
1. No contact	7%	23%	8%	33%	12%	44%	2%	14%
2. Greets Negroes in casual street encounters	15	36	26	40	26	26	26	47
3. Stops to chat in casual street encounters with Negroes	23	23	36	25	28	17	50	26
4. One or more kinds of neighborly activity	55	18	30	2	34	13	22	13
N	(73)	(107)	(77)	(95)	(113)	(145)	(58)	(138)
χ^2 =	31.9		39.0		41.2		19.0	
d.f. =	3		3		3		3	
p =	<.01		<.01		<.01		<.01	

*Thus, in general, a respondent who stops to talk with Negroes in casual street encounters (step 3) also greets them in the street (step 2). A respondent who takes part in *neighborly* interracial activity (step 4) also greets and stops to talk in casual street encounters.

TABLE 2

SUMMARY CHART COMPARING "NEARS" AND "FARS" ON VARIOUS ITEMS CONSIDERED AS INDICATORS OF PROBABLE INITIAL ATTITUDE TOWARD NEGROES

Key: = indicates little or no difference in distribution between "nears" and "fars"
+ indicates *more*, (but not significantly), "nears" than "fars" in position believed to indicate probable favorable predisposition toward Negroes
++ indicates *significantly more* "nears" than "fars" in position believed to indicate probable favorable predisposition toward Negroes
− indicates *fewer* (but not significantly), "nears" than "fars" in position believed to indicate probable favorable predisposition toward Negroes
−− indicates *significantly fewer* "nears" than "fars" in position believed to indicate probable predisposition toward Negroes

	Project A	*Project B*	*Project C*	*Project D*
Management rental policies	=	=	=	=
Refusal of apartments	=	=	=	=
Move-out rates	=	=	=	=
Original preference for proj.	=	+	=	+
Knowledge of presence of Negroes	−	−	+	=
Religion	=	=	−	=
Education	−	−−	−	++
Political attitude	+	+	−	
Prior friendship with Negroes	=	=	=	=
Prior residence near Negroes	=	+	−	=
Index of prior contact with Negroes	+	+	=	=
Attitudes of friends	+	=	=	+
Index of estimated initial attitude	=	=	−	+
Own report of prior impressions	+	=	=	−

"fars" might have differed systematically in initial attitudes: (1) factors directly related to the project situation—rental policies, refusals of apartments by prospective residents, move-out rates, preference for project, *etc.*;* (2) background characteristics or experiences known to be generally correlated with ethnic attitude—religion, education, political attitude, reported opinions of friends, *etc.*; (3) respondents' own estimates of their prior attitude toward Negroes.

The findings on background characteristics are summarized in TABLE 2. In this table, an equal sign means that "nears" and "fars" in a project differed little on the item. A single plus (or minus) means that somewhat more (or fewer) "nears" than "fars" were characterized by traits related to favorable disposition toward Negroes. A double plus or minus means that the differences between "nears" and "fars" were reliably different in that direction according to statistical tests. In only one item, education, was there a double score. In one project, "nears" had significantly more years of schooling on the average than "fars." On the other hand, in another project, "nears" had significantly less schooling than "fars."

The small differences between proximity groups in each project on the usual correlates of interracial attitude support the hypothesis that "nears" and "fars" were probably quite similar in ethnic attitude at the time of moving into the projects. An index of estimated initial attitude was constructed of five of the items appearing in TABLE 2 (political attitude, prior contact with Negroes, religion, education, and knowledge, before moving in, that there were to be Negroes in the project). Comparison of proximity groups in each project in terms of this index revealed no greater differences than on the individual items.

With regard to self-estimates of initial attitude, almost half the white residents in all projects reported predominantly negative attitudes prior to moving into the projects; and this finding is true with very little difference between proximity groups in any given project. Less than a third reported initial attitudes predominantly positive.

* Procedures for obtaining the desired information varied with the item. For example, managers were interviewed for information about rental procedures, and move-out rates were calculated from management records. We asked respondents whether, at the time of moving in, they knew Negroes were going to be living in the project. Information about the probable correlates of attitude also came from questions asked during the interview itself.

Evidence with regard to move-out rates, rental policies, *etc.*, give additional credence to the view that there were no significant initial differences in ethnic attitudes.

We conclude that the white respondents whom we have contrasted with respect to their interracial contacts were originally quite comparable to each other in range of attitudes; further, that this range included substantial members who were at the prejudiced end of the scale.

Who has the contact. The index of initial comparability made possible classification of white housewives into those whose initial attitudes were likely to be more favorable and those likely to be less favorable to Negroes. These groups were compared for level of interracial contact reached. Briefly, the findings for the initially less favorable white women living *near* Negroes were: (1) At most, 14 per cent in one of the projects had no contact with Negroes; (2) At least 57 per cent in each project had at least conversational street contact; and, (3) In three of the projects, from one quarter to one half had one or more kinds of neighborly interaction with Negroes (step 4 on index of contact).

Among white women living near Negroes, the initially less favorable were only slightly less likely than the originally more favorable to develop the more intimate forms of interracial contact.

Attitude. The "typical" prejudiced attitude of some white persons toward Negroes in the United States may be characterized as follows: Negroes are believed to be low-class, dirty, lazy, ignorant, *etc.*; the feelings accompanying these beliefs tend to be those of contempt, distrust, avoidance; thoughts about what relationships ought to be maintained with Negroes are in the direction of segregation and the assignment of Negroes to positions of inferior status.

The usual social arrangements reinforce all these dimensions of prejudice. The fact that Negroes are, in practice, assigned to inferior positions and segregated from the white majority provides support both for the view that this status is the *proper* social arrangement and, in a circular way, for the assumption that this arrangement is based on the inferiority or undesirability of Negroes. Segregation operates to reinforce prejudice in still another way. By limiting the opportunities for interaction with individual Negroes (except in situations marked by clear status differences, as in the case of employer and domestic worker), it protects the white person from having to check his beliefs against reality.

Mixed housing projects such as those we have studied represent a radical departure from the traditional social arrangements. What changes in attitudes of white residents may we anticipate from this unaccustomed proximity between the races?

Nearness of one's living quarters to those of Negroes may destroy the impression that racial separation is proper. With Negroes in the project, it may become apparent to many white residents that the governmental agency in charge considers "nearness" between the races appropriate or at least not inappropriate. Moreover, as suggested by Deutsch and Collins,[3] the actual contacts which occur among white and Negro public housing residents who live close to one another, by giving visibility to the fact of friendly relations, operate to foster the interpretation that such contacts are socially acceptable.

Because the Negroes and whites in the project are alike in many ways and of equal status with respect to the project setting, the contacts that do take place are likely to destroy the foundation for many of the prejudiced beliefs held by the white tenant.

Moreover, if the experiences that the white housewife has with Negroes in the project are at least not unpleasant, we may expect that her feelings toward Negroes will be affected.

To get an idea of the attitudes held by

white respondents after living in the projects we asked a number of questions designed to get at the various components as described above. The plan of the analysis is as follows: first we shall see how *proximity* is related to attitude. Having concluded, as above indicated, that the white proximity groups were initially fairly comparable in attitude, any difference between them must now be attributable to events occurring since they moved in. Then we shall test the general finding to see how it holds for those who were probably initially less favorable. Finally we shall seek to determine how *level of contact reached* fits in the picture of attitude change.

Proximity and attitude. Our white respondents were asked to compare white and Negro tenants in the project on seven different characteristics that figure prominently in common stereotypes. The items included such matters as cleanliness, the upbringing of children, intelligence, the care of property, *etc.* The results are as follows: On each item individually, white women living near Negroes were less likely to indicate belief in white superiority than those living farther away. A unidimensional scale composed of four of the items was then constructed. The findings for this scale are given in TABLE 3. In every project more among the "fars" were at the prejudiced end of the scale than "nears," the "fars" expressing the opinion that the races were equal in, at most, one of the characteristics. In two of the projects, "nears" were substantially more likely than "fars" to believe that Negroes and whites were equal in all four characteristics.

Feelings toward Negroes in the project were gauged by several questions related to the "esteem" in which the members of the other race were held.

The following response by a white housewife living in a mixed court is an example of an expression of positive feelings ("high esteem") for the Negroes in the project: "They are just like the white people as far as I am concerned. To me, one is the same as the other... They are always dressed neat; as clean as the white; polite, as far as I can see--very, very polite... Their home is here as well as ours. They are friendly... What more can you ask? I like the idea of mixing races because it helps promote good racial feeling. Why should there be all this talk about differences, or what you like or not? They seem to me the same in every way as the whites."

An example of the other extreme of feeling toward Negroes ("low esteem") is the response of a white respondent in a virtually all-white area: "(The Negroes in this project are) like all colored people. They

TABLE 3

PROXIMITY AND BELIEF IN SIMILARITY OF NEGROES AND WHITES IN PROJECT

Comparison of White Women Living Near Negroes with White Women Living Farther Away (by Projects)

	Project A		*Project B*		*Project C*		*Project D*	
	Near	*Far*	*Near*	*Far*	*Near*	*Far*	*Near*	*Far*
Believe Negroes and whites equal in all four characteristics	55%	28%	43%	26%	29%	22%	17%	20%
Believe Negroes and whites equal in two or three of the characteristics	32	40	47	34	50	39	65	52
Believe Negroes and whites equal in only one or none of the characteristics	13	32	10	40	21	39	18	28
N	(73)	(107)	(77)	(95)	(113)	(145)	(58)	(138)
χ^2 =	14.7		19.2		8.9		3.6	
d.f. =	2		2		2		2	
p =	<.01		<.01		<.05		>.10	

TABLE 4

PROXIMITY AND "ESTEEM" FOR NEGROES IN PROJECT

Comparison of White Women Living Near Negroes with White Women Living Farther Away (by Projects)

	Project A		Project B		Project C		Project D	
	Near	Far	Near	Far	Near	Far	Near	Far
High "esteem"	65%	43%	83%	42%	46%	31%	61%	50%
Mixed high and low "esteem"	16	25	12	14	33	24	29	25
Low "esteem"	18	32	4	35	21	39	7	23
Not classifiable	1	–	1	9	–	6	3	2
N	(73)	(107)	(77)	(95)	(113)	(145)	(58)	(138)
χ^2 =	8.9		33.5		9.8		6.7	
d.f. =	2		2		2		2	
p =	< .05		<.01		< .01		<.05	

feel as if they own the world. They push themselves. They think they're a little better than most people. I hear that some of them in this project are very nice...but I wouldn't like them living in the next row... When...they get up North and they find they can do a lot more things, they seem to take advantage of it. I suppose it's only human nature but I think they should be kept in their place..."

TABLE 4 shows how the proximit groups compared on our measure of esteem based on ratings of such responses.* In each project, reliably, white women living near Negroes were more likely than those living farther away to hold Negro project residents in high esteem and less likely to derogate them.

Other attitude items reveal essentially the same picture. Whether the item deals with the particular Negroes in the project, or with Negroes in general, whether the issue is *feeling* toward Negroes as persons, or point of view toward living with them in the same project or building, *"nears" express a point of view more favorable to Negroes than "fars"* in at least two of the projects, and generally in all four. There are never any significant reversals of this trend.

When we consider our previous conclusion that the "near" and "far" groups in a project were initially similar in attitude, *then the attitude differences just reported suggest that the more favorable attitudes now current among white housewives living near Negroes represent a change from their original attitudes.*

Who undergoes change? We can gain clearer understanding by getting answers to the question: is it only those who were already favorable initially who now simply lose the last vestige of bias, or does the proximity experience affect the originally unfavorable as well?

To obtain this information "near"-"far" comparisons were made separately on all attitude variables for the originally more favorable and the originally less favorable housewives according to their position on the index of estimated initial attitude.

The results are very similar to those already reported before respondents were separated according to initial attitude. For example, let us compare the initially less favorable housewives living near Negroes with similarly predisposed housewives living farther away. In the initially least favorable group, a greater proportion of "nears"

*Cues as to degree of proximity of residence had been eliminated at the time the ratings were made.

TABLE 5

PROXIMITY, REPORTED PRIOR IMPRESSION OF NEGROES, AND SELF-REPORT OF CHANGE IN ATTITUDE

Comparison of White Women Living Near Negroes with White Women Living Farther Away

	Project A		Project B		Project C		Project D	
	Near	Far	Near	Far	Near	Far	Near	Far
Prior Impression:	*Unfavorable*							
Reported Change in Attitude	(n=38)	(n=55)	(n=29)	(n=35)	(n=70)	(n=81)	(n=29)	(n=47)
For the better	82%	43%*	79%	43%*	56%	28%*	86%	49%*
For the worse	–	4	–	3	4	9	–	2
No change	18	53	21	54	40	63	14	49
Prior Impression:	*Favorable or Neutral*							
Reported Change in Attitude	(n=33)	(n=49)	(n=45)	(n=56)	(n=37)	(n=61)	(n=28)	(n=82)
For the better	36%	18%	13%	7%	19%	13%	11%	13%
For the worse	12	8	–	–	8	13	14	4
No change	52	74	87	93	73	74	75	83
No answer	(n=2)	(n=3)	(n=3)	(n=4)	(n=6)	(n=3)	(n=1)	(n=9)

*Differences significant at least at the .05 level of confidence as calculated by the *t* test for significance of the differences between percentages.

than "fars" in each project hold Negroes living there in high esteem, believe them the equals of whites, *etc.*; the initially more favorable hold similar views. *In other words, whatever the relative initial level of attitude, the experience of living near Negroes has resulted in more favorable present attitudes than living farther away.*

Further evidence for the interpretation that the more favorable attitudes of "nears" represents changes in attitude comes from the respondents' own evaluation of the changes that have taken place. The most striking finding comes from the examination of the reports of housewives who reported their prior impressions as decidedly unfavorable. It will be recalled that such housewives were found in approximately equal proportions in the "near" and "far" groups in each project. The reports of their self-perceived change are given in TABLE 5. In three of the projects, more than three quarters of the "nears" report changing for the better; in the fourth project more than half. In all projects, about twice as many "nears" as "fars" reported this kind of change.

Contact and attitude change. If we agree that change has taken place, what accounts for the change? The clearest answer to our question can be arrived at by examining the relationship between attitude toward Negroes and the characteristic level of interracial contact reached by those women who, according to our estimates of initial attitude, were the least favorable to Negroes at the outset. TABLE 6 provides this this data separately for the "nears" and the "fars." *The data reveal that the more intimate the contact, the more favorable the present attitude.*

Is contact the only factor? Another factor of importance seems to be the white housewife's interpretation of the interracial association going on about her. Limitation of time does not permit thorough exploration of this variable. Briefly, "nears" were more likely than "fars" (a) to report perceiving that white women in the project mingled as much with Negro women as with other white women, and (b) to report the feeling that their white friends in the project approved friendly relations with Negro residents. The perception of an informal

TABLE 6

CONTACT AND ATTITUDE AMONG THE LESS FAVORABLY DISPOSED

Comparison of White Women Having at Least Conversational Contacts with Negroes, with White Women Having Only Casual Contacts

Respondents' Residence within Project:	*Projects A and C (Combined)*				*Projects B and D (Combined)*			
	Near		*Far*		*Near*		*Far*	
Level of Contact	*Conversational or neighborly contacts*	*No contact beyond casual greeting*	*Conversational or neighborly contacts*	*No contact beyond casual greeting*	*Conversational or neighborly contacts*	*No contact beyond casual greeting*	*Conversational or neighborly contacts*	*No contact beyond casual greeting*
Esteem:								
High Esteem	56%	28%	41%	25%	76%	52%	59%	30%
Belief:								
Belief in similarity of Negroes and whites on at least 2 items of four-item scale	88	70	73	55	90	81	86	51
Generalization:								
Take least prejudiced position on scale of attitude toward Negroes in general	52	18	44	22	58	41	46	35
Reactions to living in Negro-white projects:								
Approval	53	16	48	25	73	67	70	44
N	(77)	(43)	(44)	(110)	(41)	(27)	(37)	(88)

social climate favorable to interracial association evidently plays a role in attitude change. Thus, of all women in the project, whether initially favorable or unfavorable, those most likely to hold favorable attitudes toward Negroes are the ones who had the most intimate contact *and* perceived that this level of association was approved by other white women in the project. The least favorable were those who *neither* had the contact *nor* perceived the climate as favorable to contact. Thus, it appears that contact and perception of a favorable social climate reinforce one another in producing attitude change.

What is the nature of the process? Our speculation is that it is probably as follows: moving into a housing project open to both white and Negro tenants, the white housewife enters a community in which society's strictures about marked separation between the races appear to be suspended. She now lives closer to Negroes than she has ever lived previously. Moreover, by virtue of rental policy and veterans' priority, she observes that the status of these Negro families is similar to that of her own family in many important ways. There is also a single management publishing rules and regulations which apply equally to all residents. Depending on her location in the project and typical activities that necessitate going in and out of her apartment, there is a characteristic range of possibilities for initial encounters with Negro residents, and a characteristic range of possible observations of the interaction of the same Negroes with other white women.

As time goes on, providing the white housewife lives near enough to Negro residents to pass them in the street, or to do her work or spend leisure time while Negro women similarly engaged are nearby, she is likely to develop a nodding acquaintance with them. The course of events from this point on is a function of many other factors, some systematic and some fortuitous.

At what point the process of attitude change is instigated is difficult to say from the data of this study. It may begin during the early casual meetings, when the white housewife encounters Negroes not true to stereotype, and she notes this fact. It may begin when she learns from early observation of (or personal conversation with) Negroes that their aims, aspirations, and problems are much like her own. Or it may begin only when she realizes, from her own observations and from conversations with white friends, that relatively intimate behavior with Negroes is acceptable to other white people.

Whatever the point at which change is instigated, changing attitude is likely to influence and then, in turn, be influenced by the developing contact, in reciprocating fashion. Both contact and attitude are affected by reaction to the perceived informal pressures facilitating or discouraging continued contact. When more than casual contact is feasible, a favorably perceived climate probably influences a change of attitude and thus lays the groundwork for the development of the most favorable attitudes. But even where more intimate contact is not personally feasible, the knowledge that white friends in the project are not against interracial contact permits the process of change, which has already begun, to continue to develop.

There are many details of this process that must still be described. However, deriving from the basic hypotheses of the study and congruent with its data, the preceding conceptualization provides a way of accounting for the attitude changes that have taken place for many white residents since they have lived in the project.

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DIVISION OF MYCOLOGY

A CONCEPTUAL FORMULATION OF THE STRUCTURE AND DIVISIONAL MECHANISM OF THE BACTERIAL NUCLEUS*

By EDWARD D. DE LAMATER**

This lecture has been supplemented by photographic evidence which supports the formulation of a concept for the organization and divisional mechanism of the nucleus of bacteria. This concept, in brief, is as follows. The nuclear apparatus of bacteria consists of a centriole (central body), which lies in the cytoplasm in close proximity to the nuclear membrane or nucleocytoplasmic interface at the time of division. A spindle is formed which passes through the interface or membrane and also attaches to it, and likewise attaches to the chromosomes themselves. That the chromosomes are attached to some such spindle element is indicated by the visualization of what appear to be spindle-fiber attachment points on the individual chromosomes. The spindle element is essentially fibrous, as is indicated in those photographs in which direct fibrous continuity between the centrioles and the chromosomes can be seen. The nuclear membrane or interface persists through the divisional cycle, and is pulled out during the process of division, as is indicated in those figures in which this can be directly observed.

It is felt that the evidence of Murray,[1] as well as the evidence of the author,[2,3] indicates that both drugs and fixing agents may modify the "nuclear membrane" so as to make it more stainable, thus emphasizing the continuity of this structure through the divisional cycle. The transient polyploidy induced by the action of certain selected antibiotics and antimitotic drugs also supports the view that the nuclear membrane is continuously preserved during the mitotic cycle in bacteria.[2,4] The recovery stages from these drugs likewise emphasize this point.

The configurations produced both by the antibiotics of the tetracycline group and by colchicine (the latter has been known to act as a mitotic inhibitor for several years) further support the view that bacteria possess a mitotic apparatus.[2,5] That the centriole is a definite and independent structure and is capable of independent multiplication is indicated by those photographs of cells treated with oxytetracycline, in which the result of multiplication has been directly observed. Likewise, the unipolar conditions produced by sodium-para-amino-salicylate where the attachment of the centrioles to the nuclear membrane could be observed and the centriolar division and migration was prevented, substantiate this view.

The observations on the stages of contraction of the chromosomes themselves during prophase, and the pattern of contraction which they follow strongly favor consideration of bacterial chromosomes in the same light as are those in larger cells. Not only does the process of contraction appear to be comparable, but the chromomeres to be visualized on the chromosomes also appear to be comparable. The longitudinal division of the chromosomes to chromatids likewise suggests equivalence to what is observed in the chromosomes of larger cells.[2]

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** Director, Section on Cytology and Cytochemistry, Dept. of Microbiology, School of Medicine, University of Pennsylvania, Philadelphia, Pa.

The extensive evidence supporting these views will be presented elsewhere.[3] It is felt that this evidence supports the concept that the bacteria possess a nucleus with a high degree of organization, and that the divisional mechanism is essentially a mitotic one in which the nuclear membrane persists throughout the divisional cycle.

Establishment of the structure and nature of the divisional apparatus of bacterial nuclei is especially important to those working in bacterial genetics, where a morphologic basis of heredity would increase the possibilities of proper interpretation of genetic data, and to those interested in the localization of drug action within the bacterial cell.

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STUDIES ON THE EFFECTS OF COLCHICINE ON THE MITOTIC APPARATUS OF *SALMONELLA TYPHOSA**

By EDWARD J. MINSAVAGE** AND EDWARD D. DE LAMATER

The operation of essentially Mendelian genetic systems in bacteria has been shown by Lederberg[1] and his associates. On these grounds the existence of a mitotic process in bacteria has been suspected. The development of adequate methods has permitted delineation of the intrinsic detail in the bacterial nucleus.

The present study corroborates and supplements the previous work of DeLamater[2] and his co-workers concerning the organization of the bacterial nucleus and its included chromosomes in a variety of bacteria. The presence of a distinct "nuclear membrane" and the elongation and contraction of the chromosomes during the divisional cycle is confirmed. It is felt that the intrinsic structure of the nucleus of *Salmonella typhosa*, which was shown to possess at least three visible chromosomes in the vegetative haploid state, shows its essential similarity to the nuclei of larger cells.

Studies on the action of colchicine on the bacterial nucleus were done differently than drug action studies conducted by other authors. It was considered desirable to have large, actively multiplying, more or less homogeneous populations of bacteria as the test organisms, since this would closely approach the conditions under which the action of colchicine has been observed in plants and animals. Experimentation was therefore confined to the logarithmic growth phase, as this is the period of most rapid multiplication and, hence, the period in which the mitotic cycle would most likely be in evidence. The bacteria in most of these experiments were 3.5 hours old when exposed to colchicine, at which time they numbered 1 to 2 hundred million cells per ml. of medium. This arrangement allowed 2.5 hours for observation of nuclear changes owing to drug action.

A continuous culture method provided bacteria which varied somewhat in size from day to day. Cells of sufficient size for proper cytological study of this species were thus obtained on some days.

The RNA in control cells was rendered nonstainable with the nuclear dye, an azure A-SO_2 complex, by hydrolysis for 7 to 8 minutes in 1N HCl at 60° C. Colchicine increased the optimal hydrolysis time directly as the concentration and duration of exposure were increased. In some cases the increase was as much as twofold.

Colchicine stimulated multiplication in 3.5-hour-old progeny of 72-hour-old bacteria, but inhibited multiplication in 3.5-hour-old progeny of 24-hour-old bacteria.

The oxidation-reduction balance which was most favorable for colchicine activity appeared to lie between complete aerobiosis and anaerobiosis, but has not yet been absolutely determined. Interestingly, no cytological changes in the nuclei were observed at the two extremes of oxygen tension.

Cytologically, *S. typhosa* displayed at least five different, definable responses which could be controlled in their inducement by specific concentrations of, and duration of exposure to, colchicine: (a) very long cells in which the chromosomes appear to have multiplied within the "nuclear membrane" so as to produce axial nuclei; (b) "large bodies," fusiform cells, or Y-shaped cells which contain either one dense nucleus or what are interpreted as polyploid

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**Section on Cytology and Cytochemistry, Dept. of Microbiology, School of Medicine, University of Pennsylvania, Philadelphia, Pa.

nuclei; (c) round cells which either lie free or are attached to one or two bacteria, and which contain nuclear material; (d) cells which contain one or two large, dense nuclei that appear to be polyploid; (e) cells which are filled with a large nucleus, composed of filamentous chromosomes, similar to an interphase nucleus. Responses (a) and (d) are very suggestive of the results obtained by subjecting *Bacillus megatherium* to terramycin.[2]

Colchicine was effective in a wide range of concentrations, and exerted its influence upon the bacteria for only a few hours.

If we are to accept Levan's[3] premise that polyploidization under the action of colchicine is direct evidence for the presence of a spindle and a true mitotic process, the evidence upon which this discussion is based would substantiate the concept that these bacteria possess a mitotic mechanism.

According to Ludford,[4] some mitotic poisons, such as colchicine, produce the same action on all cells which normally develop a spindle during mitosis. In these cases the chemicals presumably act on a physico-chemical mechanism common to all these cells. Since the response to colchicine by *S. typhosa* was similar to those shown in numerous plant and animal experiments, it is strongly implied that a mitotic apparatus exists in this and other bacteria.

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CYTOLOGIC STUDIES OF MEIOSIS IN *SCHIZOSACCHAROMYCES OCTOSPORUS**

By ABRAHAM WIDRA** AND EDWARD D. DE LAMATER

The first comprehensive study on the nuclear cytology of *Schizosaccharomyces octosporus* was done by Guilliermond.[1]

In the present study, the formaldehyde-basic fuchsin technique of DeLamater[2] is used to secure permanent cell mounts suitable for the study of nuclear detail. Observations are documented photographically.

Two vegetative haploid cells unite to form an ascus by means of fusion tubes. The two nuclei, polarized to discrete centrioles, then approach one another and unite to form a diploid zygote nucleus. The presence of a membrane about this nucleus is suggested. This diploid nucleus then undergoes stages of elongation, contraction, and nucleination analogous to the prophase stages of the first division of meiosis. The nuclear membrane appears to be lost during chromosome reorganization. Four discrete bodies, considered to represent tetrads, are countable at pachytene. The relative sizes of these tetrad chromosomes are as follows: 1 long (circa 1.5 micra), 1 intermediate (circa 1 micron), 2 short (0.5 to 0.7 micra).

The appearance of a unipolar spindle marks the beginning of metaphase I. Separation of the daughter centrioles and their attached spindle cones results in a typical metaphase configuration. The elongated and separating dyads are difficult to stain at anaphase I, but a constant four-stranded appearance is evident. The chromosomes then separate and contract into the telophase I stage.

The second division of meiosis is a more rapid process. At interphase II the chromosomes are less stainable and become oriented toward the centriole. The presence of a nuclear membrane is suggested. Prophase II is marked by chromosome contraction, doubling, and nucleination together with the appearance of two daughter centrioles. This stage is rapidly followed by metaphase, anaphase, and telophase II. The spindle is formed as in the first meiotic division.

The appearance of the four interphase nuclei preceding the postmeiotic mitosis is typical; *viz.*, a weakly-staining chromatic mass polarized to a deeply-staining centriole. Again, the presence of a membrane is suggested. During the interphase-prophase reorganization, the chromosomes contract and double while the daughter centrioles migrate to their metaphase positions.

Anaphase and telophase III follow and result in the formation of an octonucleate ascus. The eight nuclei undergo a final reorganization process which results in a typical interphase appearance. Ascospores appear to be formed by condensation of cytoplasm about these nuclei.

Mitosis in haploids appears to take place in the same manner as described for the postmeiotic division.

The nucleus in this organism is separate and distinct from the vacuole at all times.[3] The vacuole and its contents may be ergastic in nature.[4]

Nuclear structure and reproductional processes in this yeast follow, in general, the pattern described in higher ascomycetes.[4]

* This paper, illustrated with lantern slides, was the third of four papers presented at a meeting of the Division on April 23, 1954. This study was supported in part by a grant from the Atomic Energy Commission, Contract AT (30-1)-1341, and by a grant from Eli Lilly and Company.

** Section on Cytology and Cytochemistry, Dept. of Microbiology, School of Medicine, University of Pennsylvania, Philadelphia, Pa.

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STUDIES ON MITOSIS AND MEIOSIS IN *CHLAMYDOMONAS**

By MOSELIO SCHAECHTER** AND EDWARD D. DE LAMATER

The genetic studies of Moewus (1940) on several species of *Chlamydomonas* have stimulated further investigations of the hereditary mechanisms in this genus by Smith and Regnery (1950), Lewin (1952, 1953), and Sager (1953), among others. Knowledge of mitosis and meiosis, however, is not available in these organisms.

A study of mitosis was undertaken with *C. moewusii*, *C. dysosmos*, and *C. reinhardi*. Impression smears were made from young cultures (18 to 36 hours) and fixed in Carnoy's solution. They were then hydrolysed in 1N HCl at 60° C., and stained with 0.25 per cent azure A containing one drop of thionyl chloride per 10 ml. of dye solution. They were subsequently dehydrated by DeLamater's procedure (1951), and mounted in a resinous medium.

The pattern of mitosis does not vary greatly among these organisms, and appears to be consistent with the mechanism as it occurs in plants. The interphase nucleus reveals a chromatinic network which condenses during prophase. Maximum contraction of the individual chromosomes is observed at late prophase. Squashed preparations of cells at this stage reveal the following chromosome numbers: *C. moewusii*, 36 ± 2; *C. reinhardi*, 18 ± 2; and *C. dysosmos*, 16 ± 1. The chromosomes double as the nucleus goes into metaphase. Squashes of cells at this stage reveal approximately twice the above numbers of chromosomes, thus establishing the improbability of error in the counts owing to nonsynchronous chromosome division or owing to breakage. Exact counts could not be obtained at the present time owing to the difficulty of resolving adjacent minute chromosomes.

The elements of the achromatic figure were not seen, probably owing to their lability to acid hydrolysis. During the metaphase, anaphase, and early telophase stages, the nuclei appear as markedly condensed plates.

Meiosis was studied in *C. moewusii* with the aid of a chemically specific double stain which yields blue nuclei in both vegetative cells and zygotes, and magenta primary zygote membranes (DeLamater, Schaechter, and Hunter, 1954). Germination of zygotes was accomplished by the procedure of Lewin (1949). The period of initial illumination was extended to 40 to 50 hours.

The configurations seen during the first meiotic prophase are too minute to be interpreted with certainty. Early events consist of filamentation of the chromatin with appearance of chromatinic granules. These granules first appear to develop as aggregates of two, three, or more discrete granules arranged in paired strings, and later become arranged as masses on parallel filaments which form a concentric double ring. Diplotene-like loops and diakinesis-like configurations are observed to form within the individual masses composing the ring. The number of loops and of diakinesis-like configurations is in the order of 8 to 10. Two alternate interpretations are presented to explain the discrepancy between the number of these meiotic chromatinic units and the haploid chromosome counts. One is based upon the assumption that a normal meiotic pattern occurs, but cannot be properly visualized owing to the difficulty of resolving such small structures. The other interpretation is presented as a tentative hypothesis, and postulates a fusion of nonhomologous chromosomes into com-

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**Section on Cytology and Cytochemistry, Dept. of Microbiology, School of Medicine, University of Pennsylvania, Philadelphia, Pa.

posites which act as units during their division. This interpretation could explain the discrepancy between the number of chromosomes in this species and the 10 linkage groups found by Moewus (1940) in a closely related species, *C. eugametos*. Although the morphological evidence available does not suffice to establish either interpretation, it is felt that the meiotic events of *C. moewusii* cannot be explained by a classic pattern at the present time.

At the first meiotic metaphase a compact plate is formed which divides and remains highly chromatic until separation of the daughter nuclei is completed. A characteristic interphase occurs between the two meiotic divisions. Prophase of the second division does not show such a marked condensation of the chromosomes as is seen in mitotic prophase. Metaphase, anaphase, and telophase of the second division resemble those of the first division. Four zoospores are usually formed under the conditions used here.

Two instances of simultaneous fusion of three gametes were observed. No concomitant nuclear fusion could be seen.

Full description of this work and photographic documentation will be presented elsewhere.

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SECTION OF ANTHROPOLOGY

THE STRUCTURE OF HUMAN SPEECH*

By JOHN LOTZ**

Speech is a brief, socially conditioned, vibratory impact of the human organism upon the atmosphere, most often perceived by other organisms. The sound is usually accompanied by visual signals, partly in the form of movements of the external part of the vocal tract (*cf.* lip reading; and the suppression of such movements in ventriloquism and convict speech), and partly in the form of concomitant manual, facial, and postural gestures. We shall concentrate on the sound.

1:0. Although specialists consider most of the human brain to be a repository of symbols, man has no special organs of communication. For speech production, parts of the intersecting alimentary and respiratory tracts together serve as the vocal tract (FIGURE 1); and speech reception is part of hearing.

1:1. The air supply for speech, the vocal air, is obtained by inhalation and jaw opening, and includes the air in the nasal, oral-pharyngal, and pulmonary cavities. The esophagal and gastric air is generally separated from the vocal air and is not used in normal speech, though it is used after laryngectomy and by ventriloquists, and in some societies serves to provide a polite sign of appreciation of good food.

Within the vocal tract, the nasal cavity does not play any role in articulation; it provides a nonmodifiable passage for the air and gives a certain quality to the voice, but has no effect upon communication otherwise. During speech it is well separated from the oral and pharyngal cavities by the raised velum, which remains raised and opens only slightly even during the production of nasal sounds (FIGURE 2). Thus in speech production, only the pulmonary tract and the oral-pharyngal cavity function actively. The pulmonary tract is responsible for various levels of the larger articulatory organization (breath, stress, and syllabic pulses), whereas all the great articulatory variation of the speech-sounds is accomplished in the oral-pharyngal cavity. The latter will be called the articulatory tract. (The large size of the pharyngal cavity, which plays a decisive role in the formation of human speech, is late in phylogeny.)

1:11. Communication between the articulatory and pulmonary tracts is more restricted during speech than during breathing. The glottis is either narrowed down to a slit (voiceless sounds), or is closed and opened at nearly periodic intervals (voice), or opened suddenly (glottal stop). Thus the entire vocal tract aims at higher tensions

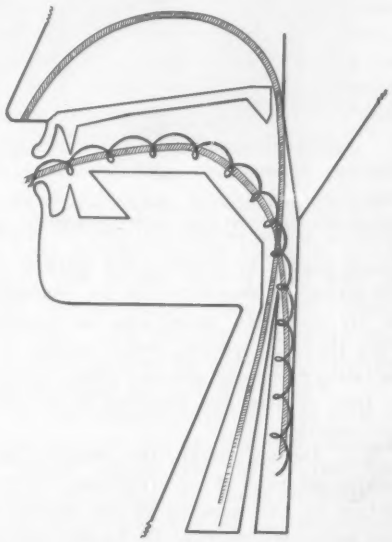

FIGURE 1. The vocal tract as intersection of the alimentary and respiratory tracts. Spiraling line: food passage; plain line: air passage.

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** Columbia University, New York, N.Y.

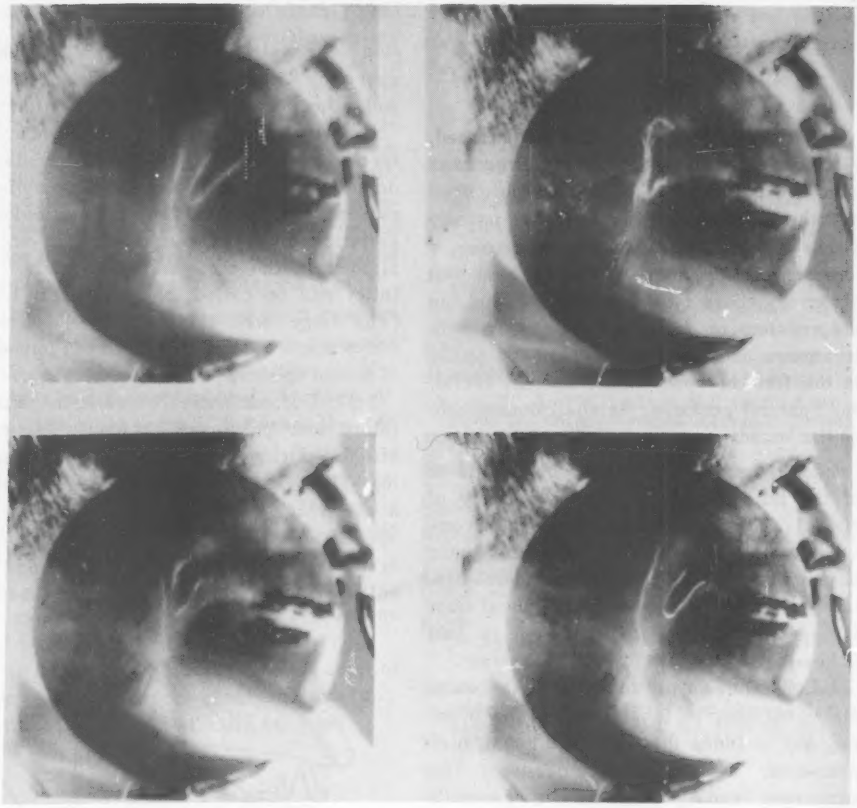

FIGURE 2. Connection between nasal and lower pharynx. Four stills from an X-ray sound motion picture. Upper left and lower right frames: beginning and end of film: no speech, velum hanging down. Upper right: non-nasal sounds, velum raised. Lower left: nasal sound, slight opening of velum.

during speech by reducing the exits so that the pressures necessary for the conversion of air flow into sound can be achieved. Only the oral opening, which serves as a radiating membrane, shows a great variability from closure and rounding to spreading and opening.

1:12. During speech, the normally slow-moving air mass of the vocal tract is set in motion by the muscles of the articulatory and pulmonary regions. By far the most important means is exhalation, but inhaled air is also used (*e.g.* Swedish *ja*↓ *jo*↓ 'yes,' especially in women's speech). During speech and singing, the air mass in motion is greater than in normal breathing, and the intake is much shorter in relation to the exhalation. Besides breathing, there are some minor mechanisms by which speech sounds are produced in some languages. These consist of a double closure, one either at the glottis (glottalized sounds) or at the velum (clicks), and the other at some point in front of them in the articulatory tract. The sound is then created by a sudden release, which may be inwards or outwards. (Thus speech cannot be said to consist solely of breath-groups.) These minor

mechanisms, however, are always built into a system based on the outgoing pulmonary air.

1:13. The air flow is converted into sounds by periodic modulation of the air stream at the glottis in the manner of a siren (voice), or by creating either a sustained turbulence (hiss) or a transient explosion (burst) anywhere along the articulatory tract where a narrowing or a closure is possible. Voice is the most effective carrier, but its distinctive role is small. These noises are then filtered by the articulatory cavities.

The transient conditions during articulation are achieved by a rapidly changing coordination of various tissue and bone structures in the vocal tract, of which the most versatile is the tongue. The various types of articulation can best be described

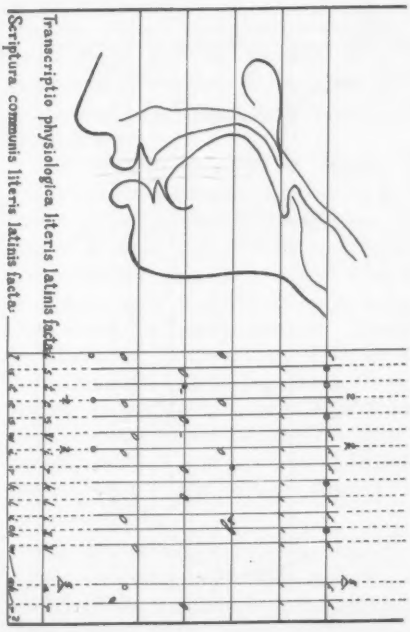

FIGURE 3. Techmer's quasi-musical representation of the German sentence, *"Ist es wirklich wahr?"*

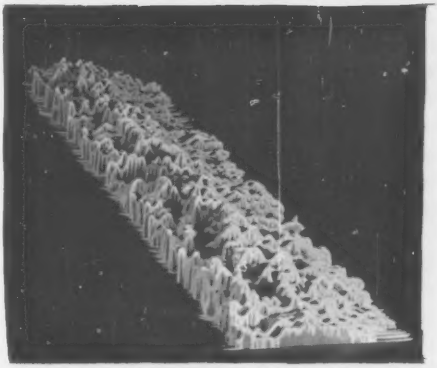

FIGURE 4. "Acoustic landscape" of the sentence, "Who will give a needle, a mouse, a cat, and a bird to my father?" with X-ray machine noise present.

by two cross-sections: (a) a medial-sagittal section showing the configuration of the lips, tongue, pharyngal walls, *etc.*; and (b) a cross-section through the center of the articulatory cavity showing the side dimensions of the passages. (Speech sounds are usually produced symmetrically, but *cf.* the right-sided *l* in Kabardian and when speaking out of the corner of one's mouth.) The description can be presented in the form of a score, as in Techmer's quasi-musical transcription (FIGURE 3). This view is the basis of componential analysis.

1:14. Dynamically, the speech process is an interlocking system of optimally filtered sounds (vowels), flanked by less optimally filtered sounds (laterals, trills, nasals) and noises with a good deal of smear and interaction (fricatives, stops, affricates). This socially determined syllabic pulse (present ontogenetically in babbling) underlies all speech processes.

1:15. The sound oscillations thus created radiate from the oral opening into the open air. Sound waves also radiate from the nostrils, chest, *etc.*, but these oscillations are not articulated and are of subordinate importance. The sound vibration is always accompanied by an air stream; the difference between the two is often not understood (*cf.* ***wh*** as a speech sound, where the

vibration is of the essence, and the same sound made in blowing out a candle, where the effect depends upon the air stream and the vibration is irrelevant).

1:16. About the underlying neural-cerebral tract not much is known that is phonetically useful. It suffices to say that more than a decade of intensive daily practice leads to a virtuoso coordination and also to petrification in the middle teens; so that after that age foreign languages are not learned without a foreign accent. The deepest psychological stratum, the intention, is also only very slightly accessible (through slips of the tongue, speech disorders).

1:21. The sound radiating from the mouth dies away at various distances dependent on the inherent energy (*cf.* Greek experiments on sonority). Speech could therefore be likened ideally to a fast-breathing balloon expanding and contracting about 3 to 5 times a second. In the actual situation, however, the obstacles – the speaker's own body to begin with, and then reverberation and absorption – make the appearance of the speech space less homogeneous.

Since all points in the speech space are equivalent for informational purposes (other than for the evaluation of distance and direction), it is sufficient to make recordings at one point only. Since the oscillogram gives a continuous single-valued function of time, the three-dimensional function of time in articulation is replaced by a one-dimensional function of time in the sound-wave. Speech oscillations are characterized by the extreme complexity of their shape and also by the extreme smallness of their dimensions. (The displacement of air particles at the threshold of hearing is one

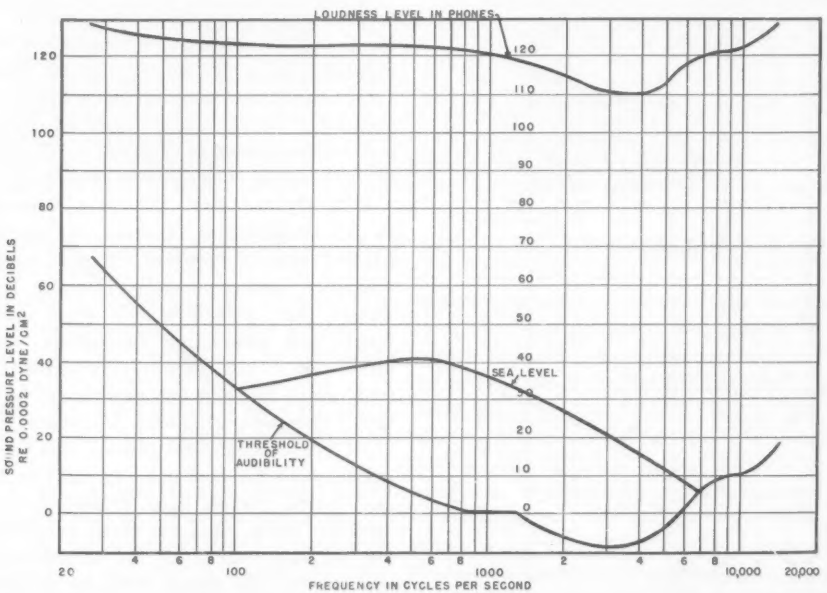

FIGURE 5. The average pressure in speech at sea level plotted against the area of hearing. (Sound pressure in speech is present from here down to the threshold of hearing.)

hundredth of the diameter of the hydrogen atom; owing to this minuteness of acoustic phenomena, most investigations make use of electrical analogues.)

1:22. The complexity of the sound wave is resolved by introducing two new parameters relevant for hearing: (1) frequency and intensity, and (2) discarding phase, which never carries any symbolic reference. This complexity gives a representation of speech in a three-dimensional frame of time, frequency, and intensity. When speech is mapped on this frame of reference it yields a great variety of cross-sectional profiles, which together give the impression of an acoustic landscape (FIGURE 4). In this analysis, frequency and intensity have restricted ranges (from 90 ~ [though in singing an octave lower has been noted] up to 13,000 ~ [present in *s* sounds], and for intensity from *ca.* 10 db to *ca.* 65 db), whereas the parameter of time is unrestricted. This limitedness in the axis of simultaneity and the freedom along the axis of successivity are important factors in the analysis of speech in terms of distinctive features.

1:31 In the reception of speech, the speaker is in a special position in so far as he gets the speech through bone-conduction as well; also, the distance between his mouth and ears is constant. Moreover, he doesn't have to interpret what is being said since he knows his own intention. This constant speech circuit of the speaker is an important controlling factor, for when hearing is impaired, speech also deteriorates. Another hearer besides the speaker, though usual, is not necessary. Therefore speech cannot be defined logically as communication.

1:32. In hearing we have: a minutely responsive mechanical and hydrodynamic system in the ear structure (the movement of the eardrum at the threshold of hearing is 0.000000001 cm. and that of the basilar membrane 0.00000000001 cm.), in which the signal remains fairly similar to the incoming signal; a neural-cerebral section (about which we know very little that bears on phonetics) and, finally, perception, which is investigated by sound and word recognition tests. (Hearing, which is phylogenetically the last perceptive sense to be acquired, is also the sense requiring the smallest stimulus to give contact with the universe.) The speech sounds are located in the most sensitive part of the auditory area (FIGURE 5).

1:33. Perceptually, hearing is characterized by the ability to resolve the complex input into constituent – probably quantized – patterns, which enables man to distinguish sound complexes originating simultaneously from various sources. For speech, the following types of perceptual categories are relevant: (1) *timbres*, which depend on the shape of the profile structure; and (2) *prosodic* features – which on the whole – are the perceptual correlates of the three parameters of the time-frequency-intensity representation: (a) *pitch*, the perceptual correlate of differences of well-organized harmonic structures along the frequency axis; (b) *loudness*, correlating with differences between intensity levels; and (c) *duration*, which corresponds to the organization of the acoustic material along the time dimension (FIGURE 6). Thus we obtain a clear model for the phonetic categories which are empirically used in linguistics. (These categories are interdependent.)

2:0. Speech has been analyzed in various ways: impressionistically; by observation, with the help of instruments; and through experimentation. On the basis of these approaches, two phonetic disciplines have grown up: *articulatory phonetics*, which treats the activity of the vocal tract and the resulting air flow; and *acoustic phonetics*, which deals with the sound wave (formation in the vocal tract, shape and propagation in the sound space) and its impact on the ear; and then sound perception, corresponding to the stimulus-response pattern of

psychophysics. For the description of speech phenomena, linguists use a mixed terminology, articulatory for timbres and impressionistic-acoustic for the prosodic features.

3:0. It is desirable, however, to get a thorough picture of each phase of speech transmission in itself, and also to follow it up through the various stages of transmission. For this purpose, X-ray sound motion pictures were made in collaboration with Doctors G. H. Ramsey, J. S. Watson, Jr., S. A. Weinberg, and R. Gramiak of the University of Rochester, and Doctor F. S. Cooper of the Haskins Laboratories. To test the usefulness of X-ray cinematography for speech-research three sample sentences were constructed:

(a) Who will give a needle, a mouse, a cat, and a bird to my father?

(b) Joe the Third cheers and treasures little show dates.

(c) He pushes ahead his spoiled boots.

(*a*, to test the median-sagittal section; *b*, the prelingual zone; and c, the laryngal region.)

When the X-ray pictures were made, optical pictures were taken simultaneously and the sound was also recorded. The results were later analyzed physically and a three-dimensional model constructed (*cf.* FIGURE 7).*

The second part of this paper deals with the internal organization and the behavioral setting of speech. The following points are made (they will be treated in full elsewhere):

1:1. There is no general or natural human speech; speech is socially differentiated

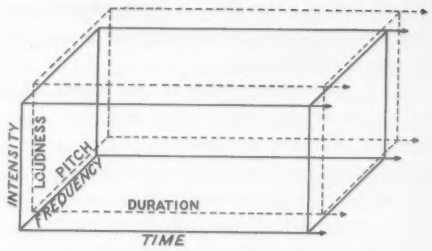

FIGURE 6. The prosodic-acoustic frame of speech. Solid lines and Roman letters indicate physical parameters; broken lines and italics, psychological parameters.

and acquired through learning. Practically every human being belongs to one—and only one—speech community. Owing to the large number of users, the large number of symbols, and the constant use of language, speech shows the greatest variability of all aspects of culture; at the same time it is semistable in time. The importance of language communities is growing with the increase of mass communication media (the dissolution of the Hapsburg monarchy took place along linguistic lines; the Soviet Union is administratively organized on a linguistic basis, and *cf.* also the recent political trends on the Indic subcontinent).

1:2. In speech, one can distinguish the symbolic/linguistic stratum (an extremely small part of the energy, less than one per cent, is used in this connection), which correlates speech with socially accepted references and the rest of the information, which includes: (a) characteristics of the speaker as a member of the species: somatic features of long and short range (*e.g.* broad pharynx, a head cold) and typological characteristics: sex, constitutional type; characteristics of personality and mannerisms; emotional moods of various kinds; attitude toward the speech event (sarcasm, benevolence, intimacy); and (b) socially determined features which often are barely separable from the personal features: social mannerisms of voice (low voice, open mouth, rhythm), stereotyped

* Here followed a showing of the film *Some Aspects of the Speech Event* at normal and at half speed, and some more recent X-ray sound motion pictures. The film was first presented at a Wenner-Gren Foundation for Anthropological Research Supper Conference, April 10, 1953, and was preceded by a lecture, *Speech Event and Linguistic Analysis* (with mimeographed abstract), the results of which are included in the present paper (*cf.* report to Doctor Paul Fejos, mimeographed abstract available). The film has since been released for scientific presentation.

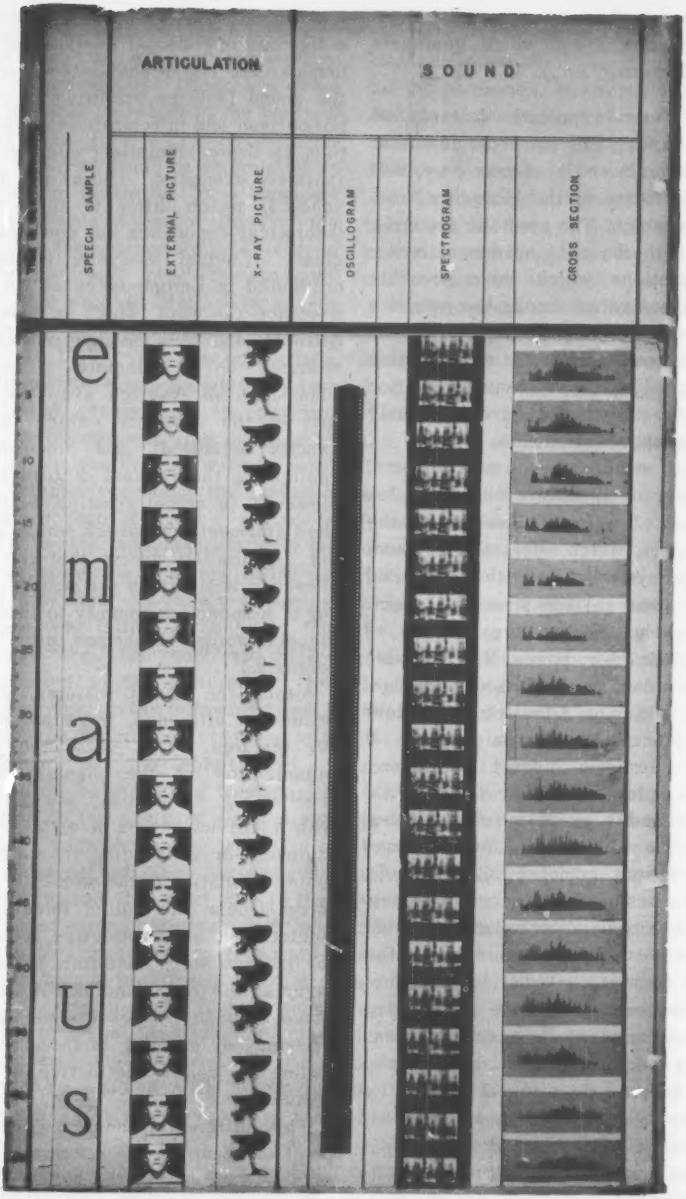

FIGURE 7. Synoptic chart of correlated stills of the phrase, "...a mouse..." Optical pictures, X-ray pictures, oscillogram, spectrograms, and cross-sections of the same speech event (the optical pictures and the cross-sections were taken at the rate of 24 frames per second, the X-ray pictures and the spectrograms at 30 frames per second).

ways of delivery (formal, preaching, advertising, announcing), and voice qualifiers (whining, whispering, *etc.*).

2:1. The most important features of human speech are the symbolic features. These are characteristic of man only, and are the main factor in the biological success of the species. The symbolic features, associated with the vast number of meaningful correlations which make possible detailed communication among the members of the same speech community, allow the formulation, preservation, and transmission of experience which give man, in addition to his genetic inheritance, a continuously accumulating cultural tradition.

Speech is structured in two aspects, corresponding to its nature as a complex signal system of articulated sound: (a) the semiotic aspect, which refers to the meaning-carrying symbols and their internal organization; and (b) the phonetic aspect, which comprehends the organization of sound for semiotic purposes. The phonetic aspect includes both articulatory and acoustic phonetics, and the transformations which take place during transmission.

2:2. The semiotic aspect of speech shows a complex hierarchy. The minimal signal is called a morpheme (*e.g.* 'cat-s' consists of two morphemes). The morphemes are grouped into complex signs: words, phrases, clauses, and sentences. The sentence is the maximal complex sign, and beyond the sentence there is no further syntactical norm of construction (this does not mean, however, that there is no carry-over). The occurrence of complex and maximal signs, a special characteristic of human speech as differing from animal communication, enables man to approximate with any desirable degree of accuracy the expressive and communicatory demands of greatly varying situations.

2:3. Analysis of the sound material has been greatly furthered during the past quarter of a century by the development of a rigorous operational analysis called phonemics. The aim of phonemics is to analyze the sound features occurring in speech by comparison and differential analysis, rather than by impressionistic characterization of isolated examples. There are two main schools, which differ in their professed theoretical departures but come remarkably close in actual analysis. Phonemics as originated in Europe takes as its frame of reference the word (which is never exactly defined), and uses meaning or meaning differences as a principle of distinction. Phonemics in America uses the physical fact of the utterance (which is nowhere exactly delimited), and proceeds by investigating the internal distribution of the elements. In actual practice, both compare short fragments of speech which are different signals. (It seems that the basis of phonemic analysis is the ability of a member of a speech community to identify short signals: words, morphemes, *etc.*, in varying contexts.)

Among the sound features which constitute an utterance, there are two types: (a) features which show the hierarchic organization of the signals on various levels: *e.g.* 'blackbird' and 'black bird', with a unifying stress or with two separate stresses, or suspending intonation or finishing intonation in the sequence 'one, two, three' (these are called integrating, configurational, or constructive features); and (b) features which constitute the elementary signals, the only function of which is to serve as sign components signals without carrying any meaning in themselves; these latter are called distinctive or phonemic features.

This differential analysis takes as its point of departure the matching of two signals on the basis of the syllabic pulsation, matching peaks with peaks (*e.g.* in 'steak' and 'takes' one matches the vocalic peaks first and not the sounds in their sequence).

This syllabic pulsation is very readily perceived and quantized, whereas enumeration of the phonemes requires conscious attention. The syllabic pulsation is the basis of poetry and song. It is culturally differentiated (*e.g.* 'Christ' would be interpreted as tetrasyllabic in Japanese). If a language has different levels of stress, the matching takes place on the appropriate level (*e.g.* in English 'pretty' and 'pity' the stressed first vowels are matched first). After matching, the peaks are compared, and then the "valleys." In both cases the comparison might yield simple elements which cannot be decomposed sequentially, or clusters which can be decomposed into successive segments (*e.g.* in the English word 'sphere' the initial cluster preceding the stressed vowel is a sequence of *s* and *f*, and not a single unit). In this analysis care must be taken to separate the features owing to smear and slur from the freely occurring features (*e.g.* the initial *k*-sounds in the English words 'keel' and 'cool' are different with respect to the features of lip-rounding, depending on the following vowel; in Kabardian, the difference between *o* and *e* is dependent upon the labialization or palatalization of the preceding consonant). The first step in the analysis gives a set of so-called microphonemes which are positionally determined; their arrangement is called distribution. The next step is the identification of microphonemes in different positions; this operation consists mainly of equating sounds in different positions which share a common sound feature; they are then said to be in complementary distribution. In rarer cases, sounds in peak positions can be equated with others in "valley" positions or vice versa (*e.g.* the *l* in English 'kettle' and the *l* in 'leak') This second set of operations yields the phonemes, which thus represent the highest level of abstraction from the sound material that does not obliterate any distinction among the signals. (For the establishment of the microphonemes, it is sufficient to have differentiation in identical position; for the phonemes, however, it is necessary that they should also share a feature, and here the procedure of linguists varies.) The phonemes occur in a sequence and are therefore called segmental. In addition there can be features which operate in the prosodic frame (*e.g.* Cantonese tonal levels and movements; also, *cf.* above.)

The phonemes can be further decomposed into distinctive features, the number of which is less than the number of phonemes (*e.g.* English *p/b, t/d, f/v,* all share the distinction: voiced/voiceless; *i, e, ɛ,* share the feature of front-unroundedness; *etc.*). The distinctive features are the absolute minima of which the signals are composed (phonemes, however, may be perceived as cohesive units.)

Phonemes and distinctive features are a specialty of human speech. They have the advantage of permitting a few sound features—easily produced and readily distinguishable—to be combined according to definite distributional patterns into the very large number of signals which make up the vocabulary of the language.

2:4. The phonemic structure of a language consists of an inventory scheme (favored by European phonemics) and the distributional pattern (cultivated mostly in America).

The inventory scheme accounts for the number of phonemes (*e.g.* in Hawaiian there are five vowel and six consonant phonemes, in Abkhazian there are two vowel and 68 consonant phonemes). In the internal organization of the scheme, there are, in addition to the prosodic features—as follows from the above—vocalic and consonantal subpatterns, which only partially match, since certain features are common to both while others are specific to one or the other (*e.g.* apical articulation is typically consonantal, whereas rounding is often shared by both). The organizing principle is stricter than

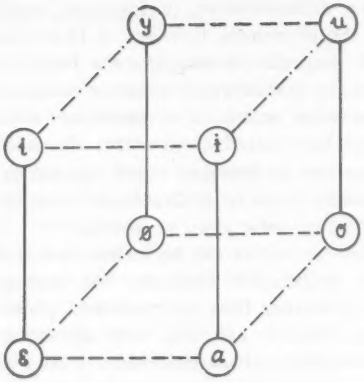

FIGURE 8. Topological structure of the Turkish vowel scheme. Solid line indicates the opposition: high-low; broken line the opposition: front-back; dotted line the opposition: unrounded-rounded.

mere differential contrast: *e.g.* the Turkish vowel system is based on three binary oppositions, and is not adequately described by a mere enumeration of the eight vowel phonemes (*cf.* FIGURE 8).

The number of distinctions in a phonemic scheme lies within the following extremes, depending on the number of terms in the opposition:

If the number of phonemes is n, then in the binary case the maximum is $2^{n(n-1)}$, the minimum number of distinctions is $\lceil \log_2 n \rceil$; where $\lceil x \rceil$ is x, if x is an integer, otherwise the next higher integer; *i.e.* $\lceil x \rceil = -\lceil -x \rceil$ in more familiar symbols.

The other extreme is one opposition with n members in a well-ordered sequence.

$$\text{maximum} \qquad \frac{n(n-1)}{2}$$

$$\text{minimum} \qquad \lceil \log_2 n \rceil$$

The actual number of distinctions is not far from the binary minimum.

The distributional pattern describes the arrangements of the phonemes in sequences (*e.g.* in Kabardian there are large consonant clusters constructed – except for a possible initial *s* – so that the order is from the lips backwards, followed by one of the two phonemes; in Finnish, *a, o, u,* cannot be combined in the same simple word with *ä; ö, y* [*cf.* FIGURE 9]; in Ostyak no consonant clusters occur initially; in the Semitic languages three consonants usually carry the lexical meaning).

2:5. There is a high degree of correlation between the semiotic and the phonetic organization of speech as far as the constructive features and the semiotic units are concerned (although the constructive features are often optional), whereas the correlation between the phonemic level and the morphemic construction is indicated only by the distribution (*e.g.* in the English cluster *-lsts,* the last *s* must be a suffix). There is, however, no direct line from phoneme or syllable to morpheme or word; these belong to different aspects of organization.

2:6. Mathematical considerations play an increasing role in the characterization of speech, especially since the development of information theory (*cf.* also word- and phoneme-statistics, topological graphs of linguistic structures, *etc.*). Though quanti-

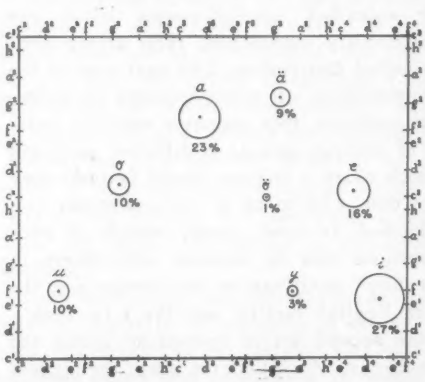

FIGURE 9. Two-formant representation of the Finnish vowels. The diameter of the circles is proportional to the relative frequency of occurrence in text. ($c^1 = 256^-$)

tative treatment is dependent on the qualitative establishment of the units to be treated, it is an integral part of the functional description of a language.

Transitional probabilities characterize both the phonetic and the semiotic aspects and their calculation can be carried out for the various levels inherent in both. A break in the sequence with a free or nearly free choice of the succeeding unit also marks the boundary of a certain construction (syllable, adjectival phrase, *etc.*).

But the simplest type of transitional probability, that of the immediate sequence of the segments, as is current in information theory, has to be extended. In speech, the the co-occurrence of constructive features and the occurrence of discrete constructions presents further problems: for instance, as regards redundancy, which can be defined only as a dependent notion if one specifies in what frame and in what respect something could be eliminated. In calculating redundancy, account must be taken not only of the usual treatment of elements immediately following in the sequence (*e.g.*, after utterance of an initial *st-*, a vowel or r must follow in English), but also of the reverse implication (in an utterance-initial triconsonantal cluster, the phoneme preceding *-tr* must be *s*), and of discrete redundancies in both directions (*cf.* the Finnish vowel harmony above, and German periphrastic perfect constructions: *ich habe . . . gemacht*). Total redundancy on any level is thus the logical sum of the progressive and regressive contiguous and discrete redundancies.

2:7. This structural approach of phonemics has developed strict methods of analysis and has been extremely successful in shedding light upon the all-important distinctive aspect of speech by setting up inventory schemes and distributional patterns, and by suggesting general typological laws of language. However, the dualistic philosophy underlying structuralism, which in speech analysis leads to a distinction between a supposedly relevant phonemics and a hybrid remainder called phonetics, is untenable. In addition to the distinctive aspect, a sound wave also contains other socially determined features such as variation attributable to the stratification of the speech-community (regional, class, and style variations); variations attributable to the position and environment in the phonemic distribution and, furthermore, features such as rhythm, base of articulation, general mode of speaking, *etc.* In addition to the social aspects, a sound wave also contains individual and emotional features, and all these factors must be incorporated into speech analysis.

3:1. Speech always occurs in a behavioral setting. The features of the situation are correlated to various aspects of the speech signal; this correlation, called meaning, is also socially determined. The relation between the signal and the reference is conventional; otherwise all languages would be identical. The relation between the elementary signals and their meaning is, moreover, arbitrary; this arbitrariness goes deep into the onomatopoetic words and interjections. The organization of the elementary signals into higher semiotic units, on the other hand, seems to be motivated by, and corresponds to the analysis of the situation by the speaker. The elementary symbols "mean" in general very indefinite things (hence the necessity for more exact definition in scientific languages); it is rather by syntactic combinations that one can approximate with any desired degree of accuracy the demands of any situation.

It is fashionable within certain trends in linguistics to exclude semantics from the scope of linguistics and to equate linguistics with analysis of the speech signal. This tendency is, of course, a question of definition of words, and as such it is not of great interest. However, when a mor-

pheme is uttered on the signal level – determined at the same time by the same social conventions – semantic references are also established; *e.g.* whenever the morpheme [*-t*] occurs in Hungarian verbs, a reference to "time prior to the reference time" is also occurring simultaneously. Therefore there is no reason to abandon the traditional inclusion of semantics within linguistics.

3:2. Speech is the only universally occurring human sign system that has no semantic limitation imposed in advance. The other sign systems are either geographically limited (sign languages among the Plains Indians, and in Australia), or culturally or socially restricted (script), or result from disability (deaf-mute signals), or are transposed systems serving superposed purposes (telephone, flag-signaling, or are of restricted reference (scientific language, trade languages). All these signal systems have in common the occurrence of elementary signs, the organization of these signs into maximal signs on various hierarchic levels up to the maximal sign within the utterance, and the sequential – not necessarily temporal – nature of the organization. The phonemic-feature level of speech, however, need not be present. Thus, we have various types of correlation among the sign systems with reference to their signal component, whereas the semantic sphere is uniform in all of them. We speak of the same language when the correlation is very high.

3:3. A common feature of all nonrestricted language systems is the inclusion of the reference to the signal itself in their semantic fields. This fact – and the occurrence of negation – account for the inherent limitations of all language systems (*cf.* the Gödel theorem, paradoxes).

CONFERENCES HELD

SECTION OF BIOLOGY

"IONIZING RADIATION AND THE CELL"

APRIL 23 AND 24, 1954

The Section of Biology held a conference on "Ionizing Radiation and the Cell." Doctor Leslie F. Nims, Brookhaven National Laboratory, Upton, Long Island, New York was the Conference Chairman in charge of the meeting.

The program consisted of the following papers:

Friday, April 23

Morning Session. Chairman: E. C. Pollard

"The Use of Radiation in Determining Biological Structures," E. C. Pollard, Yale University, New Haven, Conn.

"Radiation Studies of Proteins and Enzymes," R. B. Setlow, Yale University, New Haven, Conn.

"Bacterial Viruses: Radiation and Function," D. J. Fluke and E. C. Pollard, Brookhaven National Laboratory, Upton, Long Island, N.Y., and Yale University, New Haven, Conn.

"The Use of Variable Penetration in Studying Biological Surfaces," F. Hutchinson, Yale University, New Haven, Conn.

Afternoon Session. Chairman: K. Sax

"Effects of Chromosomal and Extra Chromosomal Irradiation on Chromosome Movements," R. E. Zirkle and W. Bloom, University of Chicago, Chicago, Ill.

"Effects of X-rays, 2 MEV Electrons, Thermal Neutrons and Fast Neutrons on Seeds of Barley," R. S. Caldecott, Brookhaven National Laboratory, Upton, Long Island, N.Y.

"Comparative Studies of X-ray Induced Forward and Reverse Mutations," N. Giles, Yale University, New Haven, Conn.

"Cytochemical Studies of Changes Induced in Cellular Materials by Ionizing Radiation," B. P. Kaufman, M. R. McDonald, and M. C. Bernstein, Carnegie Institution, Cold Spring Harbor, Long Island, N.Y.

Saturday, April 24

Morning Session. Chairman: A. O. Allen

"Iochemistry of Aqueous Systems," H. Fricke, Biological Laboratory, Cold Spring Harbor, Long Island, N.Y.

"The Effect of Ionizing Radiations on Systems of Biological Importance," E. S. G. Barron, University of Chicago, Ill.

"Studies on Factors Affecting the Sensitivity of Bacteria to High Velocity Electrons," W. Dexter Bellamy, General Electric Research Laboratory, Schenectady, N.Y.

"The Influence of Pre- and Post-Irradiation Treatments on Bacterial Inactivation by Ionizing Radiation," G. E. Stapleton, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Afternoon Session. Chairman: J. Walter Wilson

"Radiation Effects in *Paramecium*," E. L. Powers, Argonne National Laboratory, Lemont, Ill.

"The Role of Peroxide and Oxygen in the Production of Radiation Damage in *Paramecium*," R. F. Kimball, Oak Ridge National Laboratory, Oak Ridge, Tenn.

"Factors in Radiosensitivity of Mammalian Cells," H. M. Patt, Argonne National Laboratory, Lemont, Ill.

"A Review of Experiences in Modifying Radiation Response," A. Hollaender, Oak Ridge National Laboratory, Oak Ridge, Tenn.

"6-MERCAPTOPURINE"

APRIL 30 AND MAY 1, 1954

The Section of Biology held a conference on "6-Mercaptopurine." Doctor George H. Hitchings, Wellcome Research Laboratories, Tuckahoe, New York and Doctor C. P. Rhoads, Memorial Hospital Center for Cancer and Allied Diseases, New York, New York were the Conference Co-Chairmen in charge of the meeting.

The program consisted of the following papers:

Friday, April 30

Morning Session. Chairman: C. P. Rhoads

"Purine Metabolism," George B. Brown, Sloan-Kettering Institute for Cancer Research, New York, N.Y.

"Chemistry of Purine Analogs," G. H. Hitchings, Wellcome Research Laboratories, Tuckahoe, N.Y.

"Biological Activities of 6-Mercaptopurine – Microbiologic and Embryonic Effects," G. B. Elion and S. Bieber, Wellcome Research Laboratories, Tuckahoe, N.Y.; D. Hutchison, Sloan-Kettering Institute for Cancer Research, New York, N.Y.; and J. Thiersch, University of Washington School of Medicine, Seattle, Wash.

"Effects on Experimental Tumors," John J. Biesele and Donald Clarke, Sloan-Kettering Institute for Cancer Research, New York, N.Y.; Lloyd W. Law and A. Goldin, National Cancer Institute, Bethesda, Md.; and H. E. Skipper, Southern Research Institute, Birmingham, Ala.

Afternoon Session. Chairman: Murray J. Shear

"The *in Vivo* and *in Vitro* Effects of 6-Mercaptopurine on Brain Tumors," A. Gellhorn, College of Physicians & Surgeons, Columbia University, New York, N.Y.

"Pharmacology of 6-Mercaptopurine and Analogs," F. S. Philips, Sloan-Kettering Institute for Cancer Research, New York, N.Y.

"Fate of 6-Mercaptopurine in Bacteria and in Mice," G. B. Elion, Wellcome Research Laboratories, Tuckahoe, N.Y.

"Fate of 6-Mercaptopurine in Man," L. Hamilton, Sloan-Kettering Institute for Cancer Research, New York, N.Y.

Evening Session: Chairman: George H. Hitchings

"Mechanism of Action, Resistance, and Combination Therapy." Round table discussion. Participants: Donald Clarke, G. B. Elion, Charles Heidelberger, Lloyd W. Law, F. S. Philips, and Howard E. Skipper.

Saturday, May 1

Morning Session. Chairman: M. M. Wintrobe

"Natural History of Untreated Acute Leukemia," Harold Tivey, Oregon Medical School, Portland, Ore.

"Clinical Evaluation of 6-Mercaptopurine," Joseph H. Burchenal, Sloan-Kettering Institute for Cancer Research, New York, N.Y.

"Clinical Studies and Discussion:"

Frank H. Bethell, Simpson Memorial Institute, University of Michigan, Ann Arbor, Mich.

Charles A. Doan, College of Medicine, Ohio State University, Columbus, Ohio.

Byron Hall, Stanford University, San Francisco, Calif.

Mila I. Pierce, University of Chicago, Chicago, Ill.

Sidney Farber, Children's Hospital, Boston, Mass.

William Dameshek, New England Medical Center, Boston, Mass.

Wayne Rundles, Duke University, School of Medicine, Durham, N.C.

Jean Bernard, Faculté Médecin des Hôpitaux, Paris, France.

George A. Hyman, Francis Delafield Hospital, New York, N.Y.

Felipe Jimenez de Asua, Buenos Aires, Argentina.

James R. Fountain, University of Leeds, Leeds, England.
Howard L. Alt, Northwestern University School of Medicine, Chicago, Ill.
Nathan Rosenthal, New York, N.Y.
V. P. Sydenstricker, Medical College of Georgia, Augusta, Ga.
E. Clarence Rice, Children's Hospital of the District of Columbia, Washington, D.C.
Joseph M. Hill, Baylor University Hospital, Dallas, Tex.
Eugene L. Lozner, State University of New York, Syracuse, N.Y.
W. A. Newton, Jr., Children's Hospital, Columbus, Ohio.
Arthur Sawitsky, Jamaica, N.Y.
Paul C. Gaffney, Pittsburgh, Pa.
Q. B. DeMarsh, Seattle, Wash.
David Wood, University of California, San Francisco, Calif.
Sloan J. Wilson, University of Kansas, Kansas City, Kans.

"Statistical Analysis of Results with 6-Mercaptopurine," Irwin Bross, Cornell University Medical College, New York Hospital, New York, N.Y.

The Section of Biology provides conferences for active workers in the special fields of Biology.

Attendance is limited to those invited to participate in these conferences and to interested Members of the Academy.

NEW MEMBERS

Elected April 22, 1954

CORPORATION MEMBERSHIP

Sterling-Winthrop Research Institute, Rensselaer, N.Y.

SUSTAINING MEMBERSHIP

Bardoly, Louis S., M.D., Psychology. Executive Director, Roslyn Park Hospital, Roslyn Heights, L.I., N.Y.

Biederman, William, D.D.S., Biology. Assistant Professor of Orthodontics, New York University, and Private Practice, New York, N.Y.

Cipriani, André Joseph, M.D., Radiobiology. Director, Biology Division, Atomic Energy of Canada Ltd., Deep River, Ont., Canada.

Gagnon, Gerard, M.D., Surgery. Surgeon in Chief, Hotel-Dieu St. Vallier, Chicoutimi, P.Q., Canada.

Goldblatt, Samuel, M.D., Pallesthesia in Non Neurologic Diseases. Assistant Professor of Dermatology, University of Cincinnati, Cincinnati, Ohio.

Ichniowski, Casimir T., Ph.D., Pharmacology. Emerson Professor of Pharmacology, School of Pharmacy, University of Maryland, Baltimore, Md.

Johnson, Louis G., M.D., Metabolism. Assistant Professor of Medicine, McGill University, Montreal, Canada.

Peer, Lyndon Arthur, M.D., Transplantation of Tissues. Plastic Surgeon, Newark, N.J.

Piel, Gerard, B.A., Journalism. President and Publisher, Scientific American, New York, N.Y.

ACTIVE MEMBERSHIP

Allen J. Frances, Ph.D., Estuarine Ecology and Mollusks. Instructor of Zoology, University of Maryland, College Park, Md.

Amdur, Mary O., Ph.D., Industrial Hygiene and Toxicology. Research Associate, Harvard School of Public Health, Boston, Mass.

Amis, Edward S., Ph.D., Solution Chemistry, University of Arkansas, Fayetteville, Ark.

Azulay, Abraham, M.D., Internal Medicine. Private Practice, Hicksville, L.I., N.Y.

Bachrach, Samuel, M.D., Arthritis and Cancer. Physician-in-charge, Arthritis Clinic, Memorial Hospital, Worcester, Mass.

Bandy, Mark Chance, Ph.D., Geology, Mineralogy. Director and General Manager, Rhodesia Copper Ventures Ltd., Sinoia, Southern Rhodesia.

Bannon, Robert E., M.S., Physical Metallurgy. Teaching, Newark College of Engineering, Newark, N.J.

Beem, John R., M.D., Internal Medicine. Private Practice, Philadelphia, Pa.

Benfield, James Winston, D.D.S., Dental Research. Teaching Staff, Columbia University, New York, N.Y.

Berliner, Abraham, D.M.D., Histochemical Research. Research Associate in Chemistry, Rutgers University, Newark, N.J.

Bernreuter, Robert G., Ph.D., Nature of Interest, Measurement of Personality. Professor of Psychology, Pennsylvania State University, State College, Pa.

Besas, Max, D.M.D., Medicine, Dentistry. Dentist, New York, N.Y.

Best, Maurice M., M.D., Medical Research. Assistant Professor of Medicine, University of Louisville, Louisville, Ky.

Bild, Charles E., D.V.M., Physiology. Owner and Operator, Small Animal Hospital, Miami, Fla.

Blitsten, Dorothy R., Ph.D., Sociology. Instructor, Hunter College, New York, N.Y.

Bird, Herbert R., Ph.D., Nutrition. Chairman, Department of Poultry Husbandry, University of Wisconsin, Madison, Wis.

Bondurant, C. P., M.D., Biology. Professor and Chairman, Department of Dermatology, and Syphiology, Oklahoma University Medical School, Oklahoma City, Okla.

Booth, Marion F., M.D., Psychiatry. College Psychiatrist, Chairman, College Health Service, Chairman, Department Hygiene and Bacteriology, Smith College, Northampton, Mass.

Brandt, Rudolph Jos., Ph.D., Psychoanalysis. Clinical Director, Psychiatric Institute of Beverly Hills, Beverly Hills, Calif.

Browman, Ludwig G., Ph.D., Zoology. Professor of Zoology, Montana State University, Missoula, Mont.

Budowsky, Jack, D.D.S., Dentistry. Assistant Professor of Dentistry, Columbia University, New York, N.Y.

Burke, Arthur W., Jr., M.A., Biophysics. Research Associate, Institute of Biophysics, St. Louis University, St. Louis, Mo.

Burstein, M., D.Sc., M.D., Physiology. Head, Department of Physiology, National Blood Transfusion Centre, Paris, France.

Burt, Agnes S., M.D., Endocrinology. Assistant in Pathology, Massachusetts General Hospital, Boston, Mass.

Cahill, George F., M.D., Urology, Adrenal Pathology. Professor of Urology, College of Physicians and Surgeons, Columbia University, New York, N.Y.

Cattell, Raymond Bernard, D.Sc., Psychology. Research Professor, University of Illinois, Urbana, Ill.

Chalkley, Donald Thomas, Ph.D., Amphibian Regeneration. Assistant Professor of Biology, University of Notre Dame, Notre Dame, Ind.

Cimoch, Paul J., M.D., Clinical Research. Fellow in Internal Medicine, Jefferson Hospital, Philadelphia, Pa.

Cook, Robert L., D.D.S., Biology, Psychology, Anthropology. Private Practice, Dentistry, New York, N.Y.

Coonen, L. P., Ph.D., Cytology, Biology. Professor, Chairman, Department of Biology, University of Detroit, Detroit, Mich.

Coursin, David Baird, M.D., Medical Research. Director of Medical Research, St. Joseph's Hospital, Lancaster, Pa.

Darlington, James M., Ph.D., Biology. Chairman, Department of Biology, Franklin and Marshall College, Lancaster, Pa.

Davison, John P., Ph.D., Phospholipide Metabolism. Assistant Professor of Biochemistry, University of North Dakota, Grand Forks, N.D.

Dement, Alice L., Ph.D., Psychology. Associate Professor of Psychology, San Jose State College, San Jose, Calif.

De Merre, Leon J., Ph.D., Biochemistry. Scientific Staff, Medical Laboratories, Army Chemical Center, Md.

De Somogyi-Schill, Stefan, Ph.D., Psychoanalysis. Director, The Psychological Foundation, New York, N.Y.

Dominques, Frank J., B.S., Biophysics. Radio Chemist, Central Laboratories, General Foods Corporation, Hoboken, N.J.

Donnellon, James A., Ph.D., Invertebrate Blood Clotting. President, Villanova University, Villanova, Pa.

Duffy, Carl E., Ph.D., Virology. Professor of Bacteriology and Parasitology, University of Arkansas, Little Rock, Ark.

Eczacibasi, Nejat Ferit, Dr., Nat., Biology, Chemistry. President, Eczacibasi Ltd., Sirketi, Istanbul, Turkey.

Edelson, Edmond, M.D., Dermatology. Director, Department of Dermatology and Syphilology, Newark Board of Health Clinics, Newark, N.J.

Edwards, Robert Bryce, Ph.D., Immunology, Bacteriology. Director, Microbiological Research, The Lambert Pharmacal Company, St. Louis, Mo.

Elliott, Willard Buford, Ph.D., Intermediary Metabolism. Assistant Professor of Biochemistry, University of Buffalo, Buffalo, N.Y.

Ettinger, George Harold, M.D., Physiology. Dean, Faculty of Medicine, Queen's University, Kingston, Ont., Canada.

Failla, Patricia McClement, B.A., Biophysics. Research Scientist, Radiological Research Laboratory, Columbia University, New York, N.Y.

Ferguson, Edward, Jr., Ph.D., Morphology. Professor of Biology, Head of Department, State Agricultural and Mechanical College, Orangeburg, S.C.

Finnegan, Cyril V., Ph.D., Embryology. Instructor, Department of Biology, St. Louis University, St. Louis, Mo.

Friedenwald, Jonas S., M.D., Ophthalmology. Associate Professor, Ophthalmology, Johns Hopkins University Medical School, Baltimore, Md.

Friedman, Benjamin, M.D., Ophthalmology. Associate Professor, Ophthalmology, New York Medical College, New York, N.Y.

Frobisher, Martin, D.Sc., Microbiology. Special Consultant, Bacteriology Branch, Communicable Disease Center, U.S. Public Health Service, Atlanta, Ga.

Gardiner, Mary S., Ph.D., Biology, Cytology. Professor of Biology, Bryn Mawr College, Bryn Mawr, Pa.

Gee, Allen, Ph.D., Physical Chemistry. Research Associate, National Bureau of Standards, Washington, D.C.

Glover, Donald Mitchell, M.D., Tissue Transplantation. Director of Surgery, St. Luke's Hospital, Cleveland, Ohio.

Goldberg, Gus, D.D.S., Anaesthesiology. Private Practice, Dentistry, Bayside, N.Y.

Gould, Eugene E., B.S., Medical Physics. Physicist. Radiation Therapy Department, Hospital for Joint Diseases, New York, N.Y.

Green, Theron D., M.A., Virology. Laboratory Director, Clinical Investigation Branch, Camp Detrick, Md.

Greenhut, William M., D.D.S., Psychology, Medical-Dental Photography, Dental Research. Assistant Professor, Periodontia Department, New York University, New York, N.Y.

Haas, Kenneth B., Jr., D.V.M., Veterinary Medicine. Assistant, Department of Veterinary Medicine, Upjohn Company, Kalamazoo, Mich.

Handler, Fred P., M.D., Pathology. Associate Director of Laboratories, Jewish Hospital, St. Louis, Mo.

Harvey, Harriet R., Ph.D., Physiology, Endocrinology. Assistant Professor of Zoology, University of Oklahoma, Norman, Okla.

Harwood, Theodore H., M.D., Internal Medicine. Dean of Medicine, University of North Dakota, Grand Forks, N.D.

Heiffer, Melvin H., Ph.D., Endocrinology. Research Assistant, Professor of Physiology, Silver Spring, Md.

Heller, Morris F., M.D., Otolaryngology. Private Practice, New York, N.Y.

Holley, Homer R., Ph.D., Physical Chemistry. Assistant Professor, Chemistry, Loyola University, New Orleans, La.

Holmes, John R., Ph.D., Physics. Associate Professor, Physics, University of Southern California, Los Angeles, Calif.

Hoobler, Sibley W., D.Sc., M.D., Internal Medicine. Associate Professor, Department of Medicine, University of Michigan, Ann Arbor, Mich.

Horton, Charles Pinckney, D.D.S., Dentistry. Private Practice, New York, N.Y.

Howland, Joe W., D.Sc., Radiation Biology, Internal Medicine. Chief, Medical Division, University of Rochester, Atomic Energy Project, Rochester, N.Y.

Hu, Funan, M.D., Dermatology, Tissue Culture, Mycology. Research Associate, Dvision of Dermatology, Henry Ford Hospital, Detroit, Mich.

Huestis, Ralph R., Ph.D., Mammalian Genetics. Professor of Biology, Chairman of Department, University of Oregon, Eugene, Ore.

Hull, Robert N., Ph.D., Tissue Culture. In Charge Tissue Culture Research, Lilly Research Laboratories, Indianapolis, Ind.

Hume, David M., M.D., Homotransplantation. Director, Surgical Research Laboratory, Instructor in Surgery, Harvard Medical School, Boston, Mass.

Hunter, George W., Ph.D., Agricultural Biochemistry. Professor of Chemistry, South Carolina State College, Orangeburg, S.C.

Ireland, Edward J., Ph.D., Pharmacognosy, Pharmacology. Professor, College of Pharmacy, Loyola University, New Orleans, La.

Jacobs, Harry Lewis, M.A., Experimental Psychology. Graduate Assistant, Department of Psychology, Cornell University, Ithaca, N.Y.

Jensen, Dorothy Cross, Ph.D., Archeology, Assistant Professor, Anthropology and Chairman of Division, Hunter College, New York, N.Y.

Jerrold, Harry E., D.D.S., Anthropology, Biology. Chief, Dental Department, Jewish Hospital of Brooklyn, Brooklyn, N.Y.

Jones, Ruth McClung, Ph.D., Histology. Professor, Biology, Winthrop College, Rock Hill, S.C.

Kahn, Jacob A., D.M.D., Dentistry. Private Practice, New York, N.Y.

Kaufman, Louis, D.D.S., Dentistry. Private Practice, New York, N.Y.

Kaye, Saul R., D.D.S., Dentistry. Private Practice, New York, N.Y.

Keats, Martin Merrill, D.M.D., Dentistry. Prosthodontist, New York, N.Y.

Kessler, Barnett, D.D.S., Prosthodontia. Director of Dental Department, Hillside Hospital, Bellerose, N.Y.

King, Robert C., Ph.D., Radiation Genetics. Associate Biologist, Brookhaven National Laboratory, Upton, N.Y.

Kirk, John Esben, M.D., Biology, Biochemistry. Director of Research, Division of Gerontology, Washington University, St. Louis, Mo.

Kittle, C. Frederick, M.D.. Cardiovascular Surgery, Assistant Professor of Surgery, University of Kansas, Kansas City, Mo.

Kligerman, Morton, M., M.D., Radiology. Associate Professor of Radiology, Columbia University, College of Physicians and Surgeons, New York, N.Y.

Kline, Nathan S., M.D., Psychiatric Research. Rockland State Hospital, Orangeburg, N.Y.

Kobrin, Sidney, B.S., Pharmacology. Pharmacologist, U.S. Vitamin Corporation Research Laboratories, Yonkers, N.Y.

Kotin, Paul, M.D., Experimental Pathology. Assistant Professor, Pathology, University of Southern California, Los Angeles, Calif.

Krebs, Adolph Theodor, Ph.D., Biophysics, Radiobiology. Head, Radiobiology Department, Army Medical Research Laboratory, Fort Knox, Ky.

Krotkov, G., Ph.D., Biology. Professor of Biology, Queen's University, Kingston, Ont., Canada.

Lange, Jack Damgaard, M.D., Internal Medicine. Assistant Clinical Professor of Medicine, University of California,, School of Medicine, San Francisco, Calif.

Lewin, S. Z., Ph.D., Chemistry. Assistant Professor, New York University, New York, N.Y.

Lofgren, Ruth, Ph.D., Biology. Research Associate, Biology, Foundation for Integrated Education, New York, N.Y.

Ma, Tsu Sheng, Ph.D., Organic Chemistry, Microchemistry. Assistant Professor, Department of Chemistry, New York University, New York, N.Y.

Mackler, Helen, M.D., Rheumatology, Calcium Metabolism. Private Practice, Bakersfield, Calif.

Maher, Aldea, M.D., Tissue Pathology, Chemistry, Cardiology. Pathologist, Hotel Dieu Hospital, Professor, Medical Technology, Loyola University, New Orleans, La.

Majno, Guido, M.D., Bone Pathology, Enzymes. Instructor in Pathology, Harvard Medical School, Boston, Mass.

Manowitz, Bernard, M.S., Chemical Engineering. Project Engineer, Fission Products Utilization Project, Brookhaven National Laboratory, Upton, N.Y.

Marshall, John Marvin, Jr., M.D., Cytochemistry. Assistant Professor of Anatomy, University of Pennsylvania, Philadelphia, Pa.

Miller, C. Phillip, M.D., Infectious Diseases. Professor of Medicine, University of Chicago, Chicago, Ill.

Montgomery, Hamilton, M.D., Dermatology. Professor of Dermatology, University of Minnesota, Mayo Foundation, Rochester, Minn.

Morrell, Charles E., Ph.D., Physical and Organic Chemistry, Staff Chemist, Esso Laboratories, Standard Oil Development Company, Linden, N.J.

Muller, William H., Jr., M.D., Surgery, Cardiovascular Surgery. Associate Professor of Surgery, University of California, Los Angeles, Calif.

Nesbit, Reed M., M.D., Surgery, Urology. Chief, Urology Section, University Hospital, Ann Arbor, Mich.

Neuman, Robert E., Ph.D., Growth and Metabolism of Cells in Tissue Culture. Research Chemist, The Samuel Roberts Noble Foundation, Inc., Ardmore, Okla.

Newman, John P., D.V.M., Veterinary Bacteriology, Immunology. Assistant Professor, School of Veterinary Medicine, Michigan State College, East Lansing, Mich.

Nielsen, Harold H., Ph.D., Infrared Spectroscopy and Molecular Structure, Professor and Chairman, Department of Physics and Astronomy, Ohio State University, Columbus, Ohio.

Norris, Robert Fogg, M.D., Pathology. Professor, Clinical Pathology, Director, William Pepper Laboratory of Clinical Medicine, University of Pennsylvania, Philadelphia, Pa.

Oliveto, Eugene Paul, Ph.D., Organic Chemistry. Group Leader, Natural Products Research Division, Schering Corporation, Bloomfield, N.J.

Ottenstein, Bertha, M.D., Biochemistry, Mycology. Research Fellow, Medicine, Tufts College Medical School, Boston, Mass.

Pankrats, David Schultz, M.D., Embryology of Mammalian Fetal Behavior, Director, Medical

Center, Professor, Anatomy and Dean, School of Medicine, University of Mississippi, University, Miss.

Parker, Herbert M., M.Sc., Radiological Physics, Radiobiology. Director, Radiological Sciences Department, Hanford Atomic Products Operation, General Electric Company, Richland, Wash.

Pastore, Edward J., B.S., Biochemistry. Boston University, Boston, Mass.

Peller, Sigismund, M.D., Internal Medicine, Population Theory, New York, N.Y.

Peng, Chin-Tau, Ph.D., Chemistry, Biology. Assistant Research Pharmacologist, Radioactivity Research Center, University of California Medical Center, San Francisco, Calif.

Pfaus, Oscar, C., D.Sc., Literature, Anthropology, Psychology, Journalist and Writer, Hamburg, Germany.

Ponte, Franco, D.D.S., Dentistry. Private Practice, New York, N.Y.

Prescott, Blake Daniels, M.D., Medical Sciences. Neuropsychiatrist Private Practice, Springfield, Mass.

Reese, Thomas Whelan, Ph.D., Experimental Psychology. Professor of Psychology, Mount Holyoke College, South Hadley, Mass.

Renard, Suzanne G., M.D., Pharmaceuticals. Private Practice, New York, N.Y.

Revell, Samuel T. R., Jr., M.D., Hypertension. Associate Professor of Medicine, University Hospital, Baltimore, Md.

Rivers, Shirley L., M.D., Medicine, Hematology. Medical Resident, Memorial Center, New York, N.Y.

Rose, Noel R., Ph.D., Bacteriology and Immunology. Associate in Bacteriology and Immunology, University of Buffalo, Buffalo, N.Y.

Roth, Arthur L., M.D., Medicine. Senior Resident, Internal Medicine, Brooklyn Veterans Administration Hospital, Brooklyn, N.Y.

Rubin, Alan A., M.S., Pharmacology. Pharmacologist (Assistant), Schering Corporation, Bloomfield, N.J.

Salgado, Robert, D.D.S., Biology. Private Practice, Dentistry, New York, N.Y.

Salo, Torsti P., Ph.D., Biology, Physics, Chemistry. Associate Professor of Chemistry, University of Tennessee, Knoxville, Tenn.

Schulman, Milton, B.S., Biological Sciences. Instructor of Biology, New York University, New York, N.Y.

Shapiro, Donald N., D.D.S., Oral Surgery, Biology. Private Practice, Detroit, Mich.

Shipley, E. Roderick, M.D., Surgery. Associate in Surgery, University of Maryland, Baltimore, Md.

Shu, Ping, Ph.D., Fermentation Biochemistry. Research Biochemist, Prairie Regional Laboratory, National Research Council, Saskatoon, Sask., Canada.

Singer, Richard, M.D., Cardiology, Internal Medicine. Research Associate, New York Medical College, New York, N.Y.

Sippel, William L., D.V.M., Veterinary Medicine. Chairman, Division of Animal Diseases, University of Georgia College of Agriculture, Experiment Station, Tifton, Ga.

Stewart, Robert E., Ph.D., Animal Physiology, Calorimetry. Professor, Agricultural Engineering, University of Missouri, Columbia, Mo.

Stewart, Sarah E., M.D., Cancer Research, Virology. Senior Assistant Surgeon, United States Public Health Service, National Cancer Institute, Baltimore, Md.

Stewart, William Christopher, M.D., Pharmacology. Defense Research Board of Canada, Ralston, Alta., Canada.

Storer, John B., M.D., Radiobiology, Captain, Medical Corp., Army Medical Research Laboratory, Fort Knox, Ky.

Stowens, Daniel, M.D., Pediatric Pathology. Research Fellow, Pathology, Children's Medical Center, Boston, Mass.

Stryker, Garold V., M.D., Dermatology. Professor, Clinical Dermatology, Director, Department of Dermatology, St. Louis University, St. Louis, Mo.

Sullivan, Betty, Ph.D., Biochemistry. Vice President. Director of Research, Russel Miller Miling Company, Minneapolis, Minn.

Sullivan, Francis J., Ph.D., Spectroscopy. Professor of Physics, Siena College, Loudonville, N.Y.

Sundberg, R. Dorothy, M.D., Hematology. Associate Professor of Anatomy, Hematologist, University of Minnesota Hospital Laboratories, Minneapolis, Minn.

Teng, Chih-Chiang, M.D., Ophthalmology. Research Associate, Eye Bank Laboratory, New York, N.Y.

Tobin, Lester Harold, M.D., Hematology. Hematologist, Lynn Hospital, Lynn, Mass.

Towns, Myron B., Ph.D., Electrode Reactions. Professor of Chemistry and Head of Department, Tennessee State University, Nashville, Tenn.

Tsao, Makepeace, Ph.D., Biochemistry. Assistant Professor of Biochemistry, University of Michigan, Ann Arbor, Mich.

Vagtborg, Harold, D.Sc., Scientific Research Management. President, Southwest Research Institute, San Antonio, Texas.

Vallee, Bert L., M.D., Biophysics, Biochemistry. Associate in Medicine, Harvard Medical School, Boston, Mass.

Von Sallmann, Ludwig, M.D., Ophthalmology. Ophthalmologist, College of Physicians and Surgeons, Columbia University, New York, N.Y.

Van Wazer, John R., Ph.D., Inorganic and Physical Chemistry. Assistant Research Director, Inorganic Chemicals Division, Monsanto Chemical Company, Dayton, Ohio.

Watson, Michael L., Ph.D., Biology. Chief, Section of Electron Microscopy, Instructor in Biophysics, University of Rochester, Rochester, N.Y.

Weingarten, Berthold, M.D., Medicine. Assistant Clinical Professor of Medicine, Columbia University, Attending Physician, Montefiore Hospital, New York, N.Y.

Weiss, Emilio, Ph.D., Bacteriology, Virology. Bacteriologist, Chemical Corps Biological Laboratories, Camp Detrick, Md.

Wells, Franklin H., M.S., LL.D., Electric Contacts. Dielectrics. Director of Research, Aircraft Marine Products Inc., Harrisburg, Pa.

Wolf, Karl, Ph.D., Applied Physics. Chief, Department of Physical Measuring and Testing, Badische Anilin and Soda-Fabrik A.G., Ludwigshafen-on-Rhine, Germany.

Wright, Harold Noel Grant, Ph.D., Pharmacology, Toxiology. Professor of Pharmacology, University of Minnesota, Minneapolis, Minn.

Wu, Jackson S., M.D., Pathology, Medicine. Resident in Pathology, Buffalo General Hospital, Buffalo, N.Y.

Yakooleff, Joses, E. E., Electrical Engineering, Plastics. Consultant Engineer, New York, N.Y.

Yamane, George Mitsuyoshi, D.D.S., Mineral Metabolism. U.S. Public Health Service, Senior Research Fellow, University of Minnesota, Minneapolis, Minn.

STUDENT MEMBERSHIP

Gasthalter, Frank Mathew, B.A., Dentistry. Student, School of Dental and Oral Surgery, Columbia University, New York, N.Y.